SBA Shipyard
Superfund Site,
Jennings, Jefferson
Davis Parish, Louisiana

Prepared for:
SBA Shipyard PRP
Group

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Remedial Investigation/Feasibility Study Work Plan

100010183

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ACRONYMS

ADI	average daily dose
AOC	Administrative Settlement Agreement and Order on Consent
~~AOCs~~	~~areas of concern~~
~~AOIs~~	~~areas of interest~~
aRPD	apparent reduction-oxidation potential discontinuity
AST	above ground storage tanks
ASTM	American Society for Testing and Materials
AVS-SEM	acid volatile sulfide-simultaneously extractable
BAZ	biologically active zone
BERA	Baseline Ecological Risk Assessments
bgs	below ground surface
BHRRA	baseline human health risk assessment
BTV	background threshold value
CCC	Criterion Continuous Concentration
CEM	Conceptual Exposure Model
CERCLA	Comprehensive Environmental Response and Liability Act
CFR	Code of Federal Regulations
COCs	constituents of concern
COPC	constituent of potential concern
CSM	Conceptual Site Model
CTE	central tendency exposure
DGPS	differential global position system
DO	dissolved oxygen
DQOs	data quality objectives
EC	exposure concentration
Eco-SSL	Ecological Soil Screening Levels
EDDs	estimated daily doses
EHS Support	EHS Support LLC
EM	electromagnetic
EPCs	exposure point concentrations
EPH	extractable petroleum hydrocarbons
ERA	Ecological Risk Assessment
ERAGA	Ecological Risk Assessment Guidance for Superfunds
ESVs	ecological screening values
foc	fraction organic carbon
ft	foot/feet
FSP	Field Sampling Plan
GPR	ground penetrating radar
GPS	Global Positioning System
HASP	Health and Safety Plan

HHRA	human health risk assessment
HI	hazard index
HQs	hazard quotients
K	hydraulic conductivity
Koc	organic carbon partition coefficients
IAC	Investigation area of concern
IAI	Investigation area of interest
IRIS	Integrated Risk Information System
LADI	lifetime average daily intake
LDEQ	Louisiana Department of Environmental Quality
Leevac	Leevac Shipyards, Inc.
LNAPL	light non-aqueous phase liquid
LOAELs	lowest observed adverse effect levels
LOECs	lowest observed effects concentrations
NAPL	non-aqueous phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOALL	no observed adverse effect level
NOECs	no observed effects concentrations
NRWQC	National Recommendation Water Quality Criteria
OEHHA	Office of Environmental Health Assessment
ORNL	Oak Ridge National Library
PAH	polycyclic aromatic hydrocarbons
pb	dry bulk
PCBs	polychlorinated biphenyl
PCDD/PCDF	dioxins
PID	photoionization detector
PPE	possible point of entry
PPRTUs	provisional peer-reviewed reference toxicity values
PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
RAGs	Risk Assessment Guidance's
RAWP	Risk Assessment Work Plan
RECAP	Risk Evaluation/Corrective Action Program
RfCs	reference concentrations
RfDs	reference doses
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
ROD	Record of Decision
RSLs	Regional Screening Levels

SAP	Sampling and Analysis Plan
SBA	SBA Shipyard, Inc.
SBA Group	SBA Shipyard PRP Group
SLERA	screening level ecological risk assessment
SMDPs	scientific management decision points
V	seepage velocity
SVOCs	semi-volatile organic compounds
Vc	solute velocity
SOPs	Standard Operating Procedures
TAL	target analyte list
TCEQ	Texas Commission on Environmental Quality
THQ	target hazard quotient
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRVs	toxicity reference values
UCL	upper confidence level
UCL_{mean}	upper confidence of the mean
URFs	unit risk factors
USEPA	United State Environmental Protection Agency
USGS	Unified Soil Classification System
Kv	vertical conductivity
VOCs	volatile organic compounds
VPH	volatile petroleum hydrocarbons
VSP	Visual Sampling Plan
θ	volumetric conductivity
Work Plan	Remedial Investigation Work Plan

1.0 INTRODUCTION

EHS Support, LLC (EHS Support), on behalf of the SBA Shipyard PRP Group (SBA Group), is providing this Remedial Investigation (RI) Work Plan (Work Plan) for the SBA Shipyard Superfund Site located in Jennings, Jefferson Davis Parish, Louisiana (**Figure 1**). The Work Plan was developed in accordance with the provisions of the Administrative Settlement Agreement and Order on Consent (AOC) for Remedial Investigation/Feasibility Study (RI/FS) between the United States Environmental Protection Agency (USEPA) – Region 6 and the SBA Group dated October 25, 2017.

The agreed-upon objectives of the RI/FS, as stipulated in the AOC, are to:

a) Determine the nature and extent of contamination and any threat to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants at or form the Site by conducting a remedial investigation.

b) Identify and evaluate remedial alternatives to prevent, mitigate, or otherwise respond to or remedy any release or threatened release of hazardous substances, pollutants, or contaminants at or from the site by conducting a feasibility study.

1.1 Purpose

The purpose of this document is to fulfill the requirement of the AOC to submit a RI/FS Work Plan that will provide information and data to satisfy the agreed-upon objectives of the AOC related to determining the nature and extent of contamination and evaluating potential risk to human health and/or the environment. AOC-required objectives related to evaluation of remedial alternatives to prevent, mitigate or respond to contamination that poses an unacceptable risk to human health and/or the environmental are dependent upon the outcome of the RI and will be addressed under a separate work plan; thus, this work plan is referred to as the RI Work Plan throughout.

1.2 Remedial Investigation Objectives

The RI Work Plan provides a plan to collect information and data that will address key objectives of the RI. Key objectives of this RI include the following:

1. Define the nature and extent of constituents of potential concern (COPCs) in environmental media including soil, groundwater, sediment, and surface water.
2. Address data gaps identified during review of historical information, as defined in the preliminary conceptual site model (CSM) (**Appendix A**).
3. Produce a statistically defendable dataset suitable for performance of a baseline human health risk assessment (BHHRA) and screening level ecological risk assessment (SLERA).
4. Define constituents of concern (COCs) using preliminary screening criteria proposed in this RI Work Plan and evaluate potential exposure risk to human and ecological receptors via the BHHRA and SLERA processes (See **Section 3.7** and **3.8**, respectively).
5. Provide a dataset suitable for use in the FS to assess remedial alternatives to prevent, mitigate, or otherwise respond to any unacceptable risk of exposure to COCs to human and/or ecological receptors.

1.3 Remedial Investigation Work Plan Framework

This Work Plan has been developed in accordance with USEPA's RI/FS Guidance and the Statement of Work for the RI/FS provided in Appendix B of the AOC. This Work Plan is structured to allow for streamlined completion of RI tasks through an iterative and integrated investigation approach that engages project stakeholders and fosters more efficient and effective decision-making. In order to achieve the goal of streamlined completion, this Work Plan provides information related to initial data collection tasks. The SBA Group will provide interim reports or technical memorandums at key project decision points to assist in developing subsequent scopes of work as future data needs become better defined.

This Work Plan provides a general overview of each key investigation component. Work programs have been developed for the following, which are summarized further in **Section 3.0**:

- Soil Evaluation Program
- Groundwater Evaluation Program
- Surface Water and Sediment Evaluation Program

This Work Plan provides an overview of the objectives, rationale, and anticipated data collection, analysis, and evaluation approaches supported by the findings of the preliminary CSM (**Appendix A**).

In addition, this Work Plan is supported by the following key documents to ensure data collection addresses stated objectives, is focused on identified data gaps and key study questions, satisfies data quality objectives (DQOs), and that work is performed safely:

- **Appendix B** – Field Sampling Plan (FSP)
- **Appendix C** – Quality Assurance Project Plan (QAPP)
- **Appendix D** – Health and Safety Plan (HASP)

The structure of this Work Plan is as follows:

- **Section 2.0**: Current Site Understanding – Provides a summary of current site understanding based on development of the preliminary CSM and presents key data gaps and study questions used to guide proposed RI work tasks.
- **Section 3.0**: RI Work Tasks – Provides an overview of data acquisition and evaluation for each work task.
- **Section 4.0**: Supporting Documents – Provides an overview of documents specific to quality and safety to ensure work is carried out in accordance with industry standards and regulatory requirements for data acquisition, usability, and safety.
- **Section 5.0**: Deliverables and Schedule – Provides an overview of the anticipated field and deliverables schedule, which are dependent upon USEPA agreement, and staff and subcontractor availability.

2.0 CURRENT SITE UNDERSTANDING

The following provides an overview of the current Site understanding through development of the preliminary CSM (**Appendix A**). The preliminary CSM leverages existing soil, groundwater, sediment, and surface water data, previous studies and reports for the Site available to the SBA Group, and regional geologic and hydrogeologic studies to develop an understanding of the nature and distribution of contaminants in environmental media. Ultimately, the CSM is intended to serve as a living tool to identify data gaps, inform decision-making, and support development of work programs to achieve the RI Work Plan objectives identified in **Section 1.2**. Refer to the preliminary CSM for a detailed discussion of the Site operational and regulatory history, environmental setting, and current understanding of nature and extent of contamination.

2.1 Site Setting

The Site is situated on 98 acres of land in a rural-industrial area, located at 9040 Castex Landing Road, Jennings, Jefferson Davis Parish, Louisiana (**Figure 1**). The Site is located along the west bank of the Mermentau River and bordered to the north by a residential area, to the south by wetlands, and to the west by agricultural land. The Site is comprised of two separately-owned parcels; referred to herein as the Northern Property and the Southern Property. Both properties are currently inactive and are fenced with locked gates to inhibit access. During most of the operational period (from approximately 1965 to 1993), both properties were owned and operated by SBA Shipyards, Inc. (SBA). Operations on the Northern Property were historically reported to be barge and vessel construction, repair, and cleaning operations. The Southern Property was historically used for barge cleaning operations. In 1993, Leevac Shipyards, Inc. (Leevac) leased the Northern Property and continued similar operations, purchasing the property in 1998. Barge cleaning operations on the Southern property continued until approximately 2006. The Northern Property is currently owned by Bunge Street Properties LLC (formerly known as Leevac Shipyards, Inc.). The Southern Property is owned by SBA and Suzanne Smaihall Cornelius (heir of Louis Smaihall, former principal of SBA).

According to the AOC, SBA cleaned barges and other vessels that had contained a variety of materials including, but not limited to, acrylates, asphalt, carbon tetrachloride, coal tar, coke oven tar, carbon black, carbon oil, caustic soda, creosote, cumene, black oil and black oil slop, bunker crude, diesel fuel, heavy grease, wastewater, ethyl acrylates, kerosene, lube oil, methanol, number 6 oil, rust, scale, styrene, sour gas oil, soy bean oil, sulphuric acid, tallow, and vinyl acetate. SBA converted a small barge placed on land adjacent to the barge slip into the “boiler barge,” which was used to generate steam for use in cleaning barges. It also served as the barge cleaning control room. SBA used a large, partially buried barge, as well as other aboveground storage tanks constructed from cut-up barges, to store liquids, sludges, solids, and other materials generated during barge cleaning. SBA also constructed and used an unlined surface impoundment, referred to as the Oil Pit, to store liquids, sludges, solids, and other materials generated during barge cleaning. In addition to the Oil Pit, SBA used three other unlined surface impoundments, referred to as Water Pits, 1, 2, and 3, to receive wastewater, sludges and solids generated during barge cleaning. The Site layout and key site features are shown on **Figure 2**.

Interim remedial actions were performed at the Site between March 2001 and January 2005. Interim remedial actions consisted of removing, solidifying, and recycling and/or disposing wastes from the Oil Pit and Water Pit 2 offsite and then over-excavation of the basin to remove visually impacted soils; removal and scrapping of the aboveground storage tanks; draining of Water Pit 3; removing pumpable materials from the partially buried barge and disposing offsite; welding shut hatches on the partially buried barge; and scrapping of metal material from the former pit areas.

USEPA performed a second emergency removal action during 2014 and 2015 to address exposed waste material from the partially buried barge and boiler barge following reports of unauthorized scrapping of the barges and observation of liquid releases from the vessels in 2012.

Between December 2012 and September 2014, USEPA conducted preliminary site investigation activities, which included soil, groundwater, sediment, and surface water sample collection. Investigation results identified the presence of constituents of potential concern (COPCs) in the onsite soils, groundwater, the Mermentau River, and surrounding wetland areas including polycyclic aromatic hydrocarbons (PAHs), metals, and volatile organic compounds (VOCs). Dioxins/furans were also detected in a residual waste sample that was collected from exposed waste material following unauthorized 2012 scraping activities.

A more detailed discussion of site setting and historical investigation results are provided in the preliminary CSM (**Appendix A**). The preliminary CSM also contains a detailed discussion of the current site understanding and data gaps identified during review of available historical information.

Figure 2 is comprised of a 2015 aerial photograph, with current property boundaries labeled, and key Site and adjacent property features notated. **Figure 2** also provides the locations of nine potential source areas, which were identified by USEPA in historical documents, including:

- 1 – Partially-Buried Barge
- 2 – Above-Ground Storage Tank
- 3 – Former Oil Pit
- 4 – Former Water Pit 1
- 5 – Former Water Pit 2
- 6 – Former Water Pit 3
- 7 – Former Land Treatment Unit
- 8 – Barge Slip
- 9 – Dry Dock

2.2 Site Geology and Hydrogeology

Southwestern Louisiana is underlain by a thick sequence of southerly and southeasterly dipping clays, silts, and fine sand. The surficial geology for this section of the Western Gulf Coastal Plain Physiographic Province is a diverse depositional sequence of flood plain, meander-belt and backswamp deposits that were deposited in the mid-Pleistocene. These mid-Pleistocene aged sediments are part of the upper most Prairie terrace or allogroup which is partly a relict upper deltaic plain of the Red River and partly a relict upper deltaic plain of the Mississippi River that is outside of the current Mississippi River channel sediments. The Prairie terrace is now being incised by modern-day river systems like the Mermentau River. These slow-moving river systems are depositing Holocene silts and clays during flood events that are not differentiated by the Louisiana Geological Survey mapping. Due to rising and falling surface water levels throughout the Pleistocene the Prairie Complex deposits were subject to periods of flooding and drainage which may have resulted in differential settlement and the formation of vertical mud cracks, joints, concretions, slickensides, preferential root formation, and blocky structures near bedding plane surfaces.

Local geologic information is limited to fifteen boring logs and geotechnical tests completed in 1989. The soil in the upland areas of the Site is described as predominantly stiff to very stiff, low to high plasticity, oxidized silty clays to clays (with small interbedded lenses of gray to reddish brown silty sand and silt) to a total explored depth of approximately 35 feet below ground surface. The boring logs also noted the presence of slickensides, blocky structures, and shell fragments. Geotechnical compressive strength testing indicated soil failures along vertical planes, slickensides, and vertical sand seams. Descriptions of Site soil is consistent with regional descriptions of Prairie Complex deposits and indicates a predominantly fine-grained unit with interbedded zones of relatively flat-lying coarse-grained deposits potentially interconnected by vertical features observed within the fine-grained soils, depending on the extent of swelling/shrinkage that occurred post-deposition.

The Prairie Complex overlies the Chicot Group, which is a thick sequence of Pleistocene aged interbedded clays and silts in massive beds of coarse sands and gravels that were deposited in deltaic and near-shore marine environments. This formation is dipping and thickening towards the south to the Gulf Coast. The Chicot Group is divide into three sub regions in Louisiana based on the occurrence of major clay units. Towards the west in the Lake Charles Area, the massive sand and gravel beds are separated into the "200-foot", "500-foot", and the "700-foot" sands groupings.

Groundwater is generally encountered at shallow depths throughout Jefferson Davis Parish as a function of substantial annual rainfall, limited surface drainage (due to flat topography) and poorly draining soils. Shallow groundwater is present under water table and perched conditions within the Prairie terrace deposits and eventually discharges into the primary surface water bodies. In the Site vicinity, the primary discharge area for shallow groundwater is expected to be the Mermentau River.

The massive clay sequences in the Prairie Complex deposits have been identified as a surficial confining unit for the underlying Chicot Aquifer System due to their predominantly fine-grained nature. The Prairie Complex Confining Unit is extensive throughout most of southwestern Louisiana with a reported thickness at the Site being between 80 to 120 feet thick.

The Chicot Aquifer System is the primary aquifer for historical groundwater withdrawals in Jefferson Davis Parish and includes two major hydrostratigraphic units, the "upper" sand and the undifferentiated "lower" sand. Recent peer-reviewed studies reported no water withdrawals from the shallow sands in Jefferson Davis Parish.

2.3 Site Impacts

A detailed discussion of current understanding of nature and extent of impacts and conceptualized release mechanisms is provided in the preliminary CSM (**Appendix A**). The following is an excerpt from the preliminary CSM summarizing current site understanding.

Site operations on the SBA Shipyard Superfund Site were barge and tug vessel construction, cleaning and repair. Operations were ongoing between 1965 and 2006 and the Site is now inactive. The Site includes two properties – the Northern Property and the Southern Property (**Figure 2**). As a result of historical operations and post-operational activities (e.g. barge scrapping), COPCs were released to the environment. The key groups of COPCs detected at the Site, based on review of historical operations and investigation data, include:

- PAHs (and ~~limited~~ additional limited semi-volatile organic compounds [SVOCs] in waste samples)
- VOCs
- Metals
- Polychlorinated biphenyls (PCBs)
- Dioxins (PCDD/PCDF)

With the exception of metals, which may be naturally occurring within the environment, and dioxins, which are formed as a result of combustion processes such as waste incineration (commercial or municipal) or from burning fuels (like wood, coal or oil) (USEPA, 2017), these COPCs are believed to be attributed predominantly to product and residuals transported within the barges and by-products of the historical construction, maintenance, repair and cleaning operations. Products typically held in the barges include diesel, coal tar, crude oil, gasoline and asphalt.

Review of available historical documentation and investigation data has culminated in the identification of the following investigation areas of concern (IACs) and investigation areas of interest (IAIs) that require further investigation. IACs are areas where historical investigation results document potential or confirmed residuals from former site operations either in barges or in soil extending deeper than surficial soil. These areas encompass a combined area of approximately 31 acres of the 90-acre Site. The IAIs include the remaining approximately 59 acres comprised of nonoperational areas, areas with limited historical information, and/or areas where COPCs may have been transported following initial release to the environment. The location of IAIs and IACs are provided in **Figure 3**. USEPA-identified source areas and possible point entry (PPEs) for contaminants into water bodies are also shown on **Figure 3**.

- IAC-1 – Partially-Buried Barge (USEPA Source Area 1)
- IAC-2 – Boiler Barge and above ground storage tank (AST) Area (USEPA Source Area 2)
- IAC-3 – Barge Cleaning Surface Impoundments Area (USEPA Source Areas 3, 4, 5, 6, and 7)
- IAC-4 – Historical Waste Storage Area
- IAC-5 – Barge Cleaning Area Drainage Ditch
- IAC-6 – Barge Slip (USEPA Source Area 8)
- IAC-7 – Dry Dock (USEPA Source Area 9)
- IAI-1 – Southern Wetland Area
- IAI-2 and IAI-3 – Additional Land Areas on Southern Property
- IAI-4 and IAI-5 – Land Area and Barge Maintenance Area on Northern Property
- IAI-6 and IAI-7 – Vessel Slips on Northern Property

In addition, given the proximity of the Site to the Mermentau River and the potential for historical discharges to the river, the nature and extent of potential COPCs in the Mermentau River sediment and surface water require further evaluation. As discussed in **Section 3.3**, the proposed sediment and surface water sampling program has been designed in an iterative manner that allows for characterization of on-site and background sediments and surface water during the initial phase of the RI. These results will then be used to inform decision-making related to sample locations and analyses in the Mermentau River required to satisfy sediment and surface water-related RI objectives and DQOs, and to address any sediment and surface water-related data gaps and key study questions (See **Section 2.4 a**nd **2.5** below, respectively).

Based on historical accounts of Site operations, it is conceptualized that releases to the environment occurred at or near ground surface; primarily in areas where the maintenance/cleaning occurred (e.g., barge slip, dry dock) and in areas where the contents were staged or stored (e.g., the pits and barges converted into tanks, land treatment unit). Further, it is conceptualized that contaminants were released as dissolved-phase (e.g., within cleaning water) and non-aqueous phase liquids (NAPL) constituents (e.g. constituents present within fuels, oils, and residuals). Therefore, three potential primary release mechanisms have been identified at the Site:

- Surficial terrestrial releases of constituents present within NAPL, cleaning water, and other residuals within various IACs and IAIs to Site soils.
- Surficial/subsurface terrestrial releases of constituents present within NAPL and cleaning water within areas where surface impoundments were located and/or areas where source materials may have been landfilled (IAC-3 and IAC-4) to soil and groundwater.
- Surficial releases of constituents to surface water and/or sediment present within NAPL and cleaning water via barge cleaning and maintenance activities in IAC-6 and IAC-7.

Significant source removal and remedial actions have been conducted historically at the Site, largely removing the primary sources of contamination to the environment. These actions included removal/remediation of NAPL, oily water, sludges and hardened residuals, soil, and decommissioning of former operational features at the Site such as pits and tanks. While much of the primary source material has been removed, data collected to-date indicates that NAPL remains within the subsurface (IAC-3) and some areas of potential remaining sources (e.g., historical pit and landfill area; IAC-4) require further evaluation. However, based on the low mobility of NAPL observed to-date, the low solubility and low volatility of the key COPCs observed at the Site (predominantly PAHs; which would naturally adsorb to organic soils) and the fine-grained nature of shallow soils, transport of source material and COPCs away from the initial release areas is expected to be limited. Based on this information, it is conceptualized that the majority of contaminant mass remains in localized areas near former sources.

In addition to the potential presence of remaining source material, a variety of secondary transport mechanisms (e.g., via wind, surface water, and groundwater transport) may redistribute COPCs away from source areas within and across soil, groundwater, sediment, surface water, and air. While the magnitude of COPC concentrations may be significantly lower away from sources, potential human and ecological receptors have been identified on- and off-site (see **Section 3.7** and **3.8**) and thus evaluation of the nature and extent of COPCs away from source areas is warranted to assess potential risks.

Specific data gaps to complete characterization of the nature and extent of COPCs at the Site and complete an evaluation of potential risks are discussed in the following section.

2.4 Existing Data Gaps to be Addressed

As discussed in the preliminary CSM, samples have been collected and analyzed during multiple investigations, including recent sampling events in 2013 and 2014. The data collection efforts were generally targeted to locations proximal to known sources, and the results indicated the presence of COPCs. Additional data collection, to confirm the magnitude and extent of COPCs related to site operations, is necessary to fulfill the requirement of determining the nature and extent of COPCs, as specified in the AOC.

Key data gaps for all potentially-affected media include understanding the nature and extent of COPCs in environmental media and collecting sufficient data for the development of human health and ecological risk assessments. Data gaps specific to each potentially-affected media are detailed below. Ultimately, closing the identified data gaps are intended to provide confidence of the following:

- Success of historical remedial efforts in removing sources and associated COPCs from the environment
- Nature and extent of remaining source materials and associated COPCs in the surrounding environmental media
- Nature and extent of COPCs in various environmental media in areas away from sources
- Current and future risks to human health and the environment associated with historical Site-related operations

Further discussion of data gaps associated with soil, sediment, groundwater, and surface water are provided in the preliminary CSM (**Appendix A - Section 8**).

2.5 Key Study Questions

Key study questions were developed to guide RI activities and ensure that RI objectives are satisfied, DQOs met, and key data gaps are addressed. The following key study questions were provided to, and discussed with, USEPA and the Louisiana Department of Environmental Quality (LDEQ) during the RI planning and scoping meeting held on March 30, 2017. DQOs are presented in the QAPP (**Appendix C**). RI objectives and key data gaps are discussed in **Sections 1.2** and **2.4** of this work plan, respectively. The work tasks and investigative program were developed to address the following key questions. As stated in the AOC, the RI is intended to be an iterative process, with subsequent data needs identified based on results and observations from the previous phase of work. The results of the activities described in this RI Work Plan will be used to guide additional scopes of work and, ultimately, to prepare the final RI Report.

Media	**Key Investigation Questions to Answer as Part of RI/FS Activities**
Soil	What is the nature and extent of potential releases to soil in the vicinity of the partially-buried barge and boiler barge areas?
	What is the nature and extent of remaining contaminated subsurface soils in the area of the former pits and the former landfill area?
	Do subsurface soil impacts extend into the saturated zones and, if so, are subsurface soil impacts acting as a potential continuing source for groundwater contamination?
	What are the physical and chemical characteristics of residual NAPL in soils?
	What is the lateral and vertical distribution of NAPL impacts in soils?
	What is the physical nature and extent of waste materials deposited in the former landfill area?
	With the exception of soils in the former pit areas and former landfill area, are soil impacts limited to surface and near surface soils?
	What is the nature and extent of the asphaltic hard black asphaltic material that was placed at the surface throughout the site?
	Has hard asphaltic black material placed at the surface impacted surrounding and underlying soils?
	What are the potential terrestrial receptor communities present at the site?
	Do surface soil impacts pose a threat to human health and/or the environment?
River and Wetland Sediment	What is the nature and extent of sediment contamination in the drainage ditch located between the barge slip and the former pit areas?
	What is the nature and extent of impacts to sediment in the dry dock and barge slip?
	Are sediment impacts in the dry dock and barge slip limited to upper sediments only?
	Have contaminated sediments migrated beyond the dry dock and barge slip?
	Have historical activities in the pit area and barge slip resulted in sediment contamination along the northwestern and northeastern edges of the southern wetland area? If so, are sediment impacts limited to those areas in close proximity to former work areas or do they extend farther into the wetland?
	Have historical activities in the two smaller vessel slips, located on the northern property, resulted in sediment impacts?
	What is the extent of the bioavailable zone of interest?
	What are the potential benthic species communities present in sediments at the site?

Media	Key Investigation Questions to Answer as Part of RI/FS Activities
	Do sediment impacts pose a threat to human health and/or the environment?
Groundwater	What are the direction(s) of groundwater flow across the site?
	Have historical releases and/or waste placement resulted in shallow groundwater contamination?
	If historical releases and/or waste placement have resulted in shallow groundwater contamination, is contaminated groundwater in hydraulic communication with surface water?
	What is the nature and continuity of coarser-grained inclusions within the saturated portion of the overall clay matrix, and are these an important mechanism for contaminant transport in groundwater and between groundwater and surface water?
	What is the fate and transport of constituents in groundwater, and how do soil properties and geochemical conditions in groundwater contribute to the attenuation of NAPL and dissolved phase impacts?
	What is the mobility and recoverability of NAPL at the site?
	Do historical releases have the potential to impact the underlying Chicot aquifer?
	Do potential groundwater impacts pose a threat to human health and/or the environment?
	Are there potential groundwater users in the area that may be receptors (i.e., groundwater wells, etc.)?
	What is the impact of tidal and seasonal influences on groundwater elevations and flow?
Surface Water	Have historical releases resulted in surface water contamination?
	If historical releases have resulted in surface water contamination, what is the scope and extent of surface water contamination?
	Are there contamination sources from other environmental media (including partitioning from sediment to surface water and flux of impacted groundwater) that have the potential to impact surface water quality in the future?
	What are the potential aquatic receptor communities present in the River?

3.0 REMEDIAL INVESTIGATION WORK TASKS

The following provides an overview the proposed RI work tasks and a discussion of how work tasks will address RI objectives, data gaps identified during development of the preliminary CSM, and/or key study questions guiding RI activities. The RI work tasks are organized as follows:

- Global Positioning System (GPS) Survey of Site Topography and Black Asphaltic Material Placed on the Surface at the Site
- Soil Evaluation
- Sediment and Surface Water Evaluation
- Background Sampling
- Groundwater Evaluation
- Human Health Risk Assessment
- Ecological Risk Assessment

The tasks outlined in the following sections are intended to serve as a summary of the currently proposed scope of work. Additional field tasks will be developed and implemented in an iterative manner as initial tasks are completed, data is evaluated, and additional data needs are refined.

Field activities will be completed in accordance with EHS Support Standard Operating Procedures (SOPs), as detailed in the FSP (**Appendix B**).

A summary of the proposed analytical sampling program, organized by IAC and IAI, is provided in **Tables 1** through **4** as follows:

- **Table 1** – Proposed Soil Sampling Program
- **Table 2** – Proposed Sediment Sampling Program
- **Table 3** – Proposed Surface Water Sampling Program
- **Table 4** – Proposed Groundwater Sampling Program

An overview of the sample locations proposed during the initial phase of the RI is provided as **Figure 4**. Media-specific proposed sample locations are provided as **Figures 5** (soil), **Figure 6** (sediment and surface water), and **Figure 7** (groundwater).

3.1 GPS Survey of Site Topography and Black Asphaltic Material Placed on the Surface at the Site

Prior to analytical sample collection or soil disturbance activities commencing, a GPS survey will be completed to delineate the extent and thickness of the black asphaltic-like material that has been observed on the surface throughout the Site. The thickness of the material will be manually measured and recorded in the field as supplemental information, should GPS data not provide sufficient resolution to determine material thickness. In addition, GPS surveying will be completed across the Site to map surface topography. The topographic survey will include key site features such as remaining structures, the footprint of the boiler barge and partially buried barge, and the onsite drainage features that bisects the Southern Property. A topographic map will be developed to aid in evaluation of potential surface drainage that may affect contaminant distribution.

The GPS survey will be conducted by a professional land surveyor licensed to work in Louisiana. GPS resolution will be suitable to map surficial material and surface topography with an accuracy resolution of one foot or less.

3.2 Soil Evaluation

The soil sampling program approach utilizes a combination of systematic (i.e., grid-based system) and judgmental (i.e., biased) locations designed to ensure a comprehensive and statistically defensible dataset for the use in the RI and risk assessments. Proposed soil sample locations are shown on **Figure 5**. The systematic soil sampling locations were determined using Visual Sampling Plan (VSP) software developed by Pacific Northwest Laboratory. Sponsors of this public domain software include the USEPA, US Department of Energy, US Department of Defense, and other government agencies. The software identifies the appropriate number and locations of environmental samples to ensure that the results of the statistical tests performed provide information suitable for statistically defendable decision-making for risk assessors. VSP software provides sample-size equations or algorithms needed to specify statistical tests appropriate for specific environmental sampling objectives. The systematic sampling plan was designed to ensure a 95% confidence limit that a reasonably-sized hot spot would be detected within a specified polygon, if present. Hot-spot sizes were determined based on professional judgement and consideration of historical property use in various portions of the Site. In general, the number of samples within each polygon ensures a 95% confidence level that a hot-spot of at least 100 feet wide will be detected. Input and output parameters for the VSP software are provided **Appendix E**.

Judgmental sample locations were selected based on thorough review of available information concerning historical operations and previous analytical samples collected by USEPA during preliminary site assessment work. Samples were biased in areas of known contamination (as identified during previous environmental investigations) or areas where contamination is anticipated to be present (as determined by review of historical documentation of Site operations). The judgmental sample locations were selected to confirm the presence of known or anticipated contamination and to provide additional information about the scope and extent of contamination.

3.2.1 Systematic Sampling

Proposed systematic sample locations are shown on **Figure 5a**. A total of 87 systematic sampling locations are proposed at part of the initial phase of RI. The systematic sampling approach will be utilized in areas of the Site without documented evidence of releases and/or in areas where surface soil conditions have not been adequately characterized. Surface soil sample quality will be used to assess potential exposure risk to human and ecological receptors. Because exposure risk to human and ecological receptors is greatest in surficial soils, systematic sampling is proposed for the upper one foot of soil (USEPA, 2015b).

Soil samples will be obtained using a macrocore or dual-tube sampler affixed to a direct-push (e.g. Geoprobe) drill rig. The sampler will be driven to one foot (ft) below ground surface (bgs). The soil sample will be collected in an acetate liner placed inside the sampler. The acetate liner will be removed from the sampler and cut open. The field geologist will describe the general soil lithology~~, screen the sample with a photoionization detector (PID),~~ and document additional information including, presence of fill and/or native material, staining/discoloration, and odor. Due to the shallow sample interval (0 – 1 ft bgs), it is envisioned that information for each systematic sample location will be recorded on a table in the field for use in future evaluations and reports. Boring logs will not be generated for systematic sample locations. GPS coordinates for each sample location will be recorded in the field using a hand-held GPS device and flagged for future surveying.

A representative sample will be collected at each systematic boring location to be analyzed for PAHs, target analyte list (TAL) metals, geochemical, and physical property analyses. A summary of the systematic sampling program is provided in **Table 1**. Soil samples will be placed directly into laboratory supplied glassware. Samples containers will be properly labeled, placed directly on ice, and shipped under chain of custody by Eurofins Laboratories. Sample collection, chain-of-custody, and sample handling procedures are described in the QAPP and FSP. Following sample collection, the borehole will be backfilled with bentonite chips.

3.2.1.1 Northern Property Systematic VOC Sampling Program

At every other systematic sample location in the Northern Property (i.e., IAI-4 and IAI-5), surface soils will be screened for organic vapors in accordance with the procedures described in Louisiana Department of Environmental Quality's (LDEQ) Risk Evaluation/Corrective Action Program (RECAP), Appendix B (LDEQ, 2003) guidance document. A representive portion of soil will be placed in a clean 16-ounce glass containe~~d~~r, covered with clean aluminum foil, and sealed. The soil in the container will be allowed to volatilize for approximately 15 minutes prior to conducting headspace screening analysis by penetrating the foil with the probe from a photoionization detector (PID). If PID headspace readings from a systematic sample location on the Northern Property exceed 10 parts per million (ppm), a second soil sample from 0 – 1 ft bgs will be collected from directly next to the original location and analyzed for VOCs. VOC analysis will be peformed in addition to the analyses proposed at all other systematic sample locations (PAHs, TAL metals, geochemical, and physical property analyses). If PID headspace readings are 10 ppm or lower, no additional VOC sample will be collected at that location. If a VOC sample is collected, it will be properly labeled, placed directly on ice, and shipped under chain of custody to Eurofins Laboratories. Sample collection, chain-of-custody, and sample handling procedures are described in the QAPP and FSP.

Organic vapor screening and VOC sampling is not proposed for systematic sample locations on the Southern Property due to historical USEPA sample data indicating VOCs are not a key risk driver in surface soils and the spatial density of proposed judgmental sample locations, which will include VOC analysis (see **Section 3.2.2** for discussion on judgmental sampling program).

~~3.2.1.1~~3.2.1.2 Soil Sampling When Asphaltic Surficial Material is Encountered

The presence of asphaltic-like black material has been observed throughout the Site. The extent of the and thickness of the material will be mapped as part of RI activities, as described in **Section 3.1,** to determine extent and volume of the material. When a proposed systematic sampling location is located atop the asphaltic material, the boring location will be moved in the closest direction so that the boring is advanced in soil not covered by the material. The boring will not be advanced through the asphaltic material to ensure sample results are reflective of soil conditions and not the residual material. Disturbing the material creates the potential for soil and residual material to become intermixed, generating a sample that is not be reflective of soil conditions. After repositioning the boring location, sampling will be conducted as described above in **Section 3.2.1**. The composition of the asphaltic surficial material will be determined by collection of analytical samples, as described in **Section 3.2.4**.

3.2.2 Judgmental Sampling

Proposed judgmental sample locations are shown on **Figure 5b**, and include sampling points on both the Northern and Southern properties. A total of 131 judgmental locations are envisioned based on understanding of current site conditions and review of available historical information; however, the final number of judgmental sample locations will ultimately be determined based on field observations. Judgmental samples are proposed in areas of known or suspected contamination and will be used for delineation of residual soil impacts. Soil borings will be advanced using direct push drilling technology or equivalent to characterize subsurface soil conditions and facilitate collection of subsurface soil samples. Each boring will be continuously cored to approximately five feet beyond encountered groundwater. Soil boring advancement shall be completed using a dual-tube or other outer isolation casing method to prevent sloughing and potential downward migration of any overlying soils. Soil borings will be continuously logged for lithologic characterization in general accordance with Unified Soil Classification System (USCS) guidance and will document additional information including the recovery length, presence of fill and/or native material, staining/discoloration, odors, the presence of groundwater or perched water, and the the presence of NAPL~~, and photoionization detector (PID) readings. PID readings will be collected in one-foot intervals throughout the boring~~. Soils below one ft bgs will be screened for organic vapors in accordance with the procedures described in LDEQ's RECAP, Appendix B (LDEQ, 2003) guidance document, as described above in **Section 3.2.1.1.** Soils will be screened in two-foot increments and recorded on the field boring log.

Soil samples will be collected from up to ~~three~~ four depth intervals for chemical analyses, geochemical, and physical parameters, as summarized on **Table 1**. The following soil sample intervals will be collected at each judgmental sample location, regardless of PID headspace readings and/or visual or olfactory indications of contamination:

1. Surface soil sample: 0 to 1.0-foot bgs: If soils below 1.0-foot bgs do not register PID headspace readings and no visual or olfactory evidence of soil impacts are observed, only the two aforementioned samples will be collected.
2. Soil-groundwater interface soil sample: 1.0-foot interval directly above the groundwater table:

If PID readings are registered from soils below 1.0-foot bgs and/or if visual or olfactory evidence of soil impacts are observed, additional discretionary samples may be collected from the following intervals:

3. Subsurface soil sample: Soil interval exhibiting highest PID reading. If no PID readings are registered, the sample may be taken from a zone exhibiting evidence of impacts via visual or olfactory observations.
4. ~~1.~~ Lower bound soil sample: 1.0-foot interval directly below area of observed contamination (as determined by PID headspace readings or visual indicators) or 1.0-foot interval directly above the groundwater table, if evidence of impacts extends into groundwater.

Surface soil sample analyses will include ~~SVOC~~PAHs, metals, and geochemical and physical property analyses (see **Table 1** for detailed sampling plan). Subsurface and lower bound samples will also include VOC analysis. Note that the samples collected from Northern Property will also be analyzed for additional SVOCs, as described in **Section 3.2.2.1** below. VOC samples will be collected directly from a chosen interval, and then sufficient volume of soil required for remaining sample containers will be homogenized for collection of remaining samples. ~~VOC analysis is not proposed for surface samples due to the age of waste deposition as indicting that VOC compounds would have naturally volatized over time.~~ Further discussion of the waste deposition and conceptualized release mechanisms are provided in the CSM (**Appendix A**).

If NAPL is encountered, a soil sample will be collected from the 0.5 ft interval containing the observed NAPL. Additional NAPL characterization will be completed as described in **Section 3.4.4.**

Analytical methodology and requirements is presented in the QAPP, provided in **Appendix B**.

3.2.2.1 Northern Property Judgmental Sampling Program

The Northern Property judgmental sampling program will be the same as described above except that the full suite of SVOC compounds reported in the USEPA SWA-846, method 8270 will be analyzed and reported instead of the PAH subset proposed for the Southern Property. As described above, VOC analysis will be included for samples collected below the upper one foot. The full 8270 SVOC suite will be analyzed from samples collected at the 14 initial judgmental locations planned for the Northern Property. The 14 initial judgmental locaitons include the two off-site sample locations, but do not include four locations within the historical pit (1960s – 1970s), which is partially located on the Northern Property (see **Figure 5b**). Samples from these judgmental locations on the Northern Property will be collected prior to the start of systematic sampling activities on the Northern Property to confirm that potentially present SVOC constituents are limited to PAH compounds. If additional SVOC compounds are detected, the sampling program for the Northern Property will be expanded to include the full 8270 SVOC suite of compounds. If sampling confirms that SVOC constituents are limited to PAH compounds, then SVOC samples collected on the Northern Property as part of the system sampling program will be analyzed for PAH compounds only.

3.2.3 Subsurface Exploratory Surveys in Reported Landfill Area

Subsurface exploratory activities are proposed to determine the potential presence subsurface waste deposit areas reported in IAC-4 in historical reports, as shown on **Figure 3**. As discussed in the preliminary CSM, previous reports indicated that historical practices included depositing paint cans and other debris at the Site in the area between the barge slip (IAC-6 and the dry dock (IAC-7). Ground penetrating radar (GPR) and electromagnetics (EM) surveys will be used to identify subsurface anomalies that may be associated with landfilling activities. Prior to the surveys, the transects will be mowed and removed of any debris and obstructions that would impair adequate GPR/EM survey access. The GPR/EM operator will provide the field technician with a summary of all subsurface findings in real time, and the operator will provide a written summary report following completion of the survey efforts.

If GPR/EM survey results or inconclusive or if site conditions make surveying impractical or ineffective, alternative methods will be used to determine the presence or absence of potential waste material in the area. Exploratory soil borings may be advanced in the area to determine if residual waste is observed in the soil core. Alternatively, trenching may be completed using an excavator or similar heavy equipment appropriate for the task. The methodology will ultimately depend on site conditions and initial observations of the area obtained during implementation of the soil evaluation program (see above). If trenches are advanced, trench rows will be dug every 50 ft along each transect to a depth of approximately four ft bgs. Each trench will then be examined for indications of contamination or residual wastes, including but not limited to visual (e.g., staining), and olfactory (e.g., a detected odor) indicators.

Subsurface surveying or trenching will be supplemented by judgmental soil borings to determine the nature and extent of contamination. GRP/EM survey, exploratory soil borings, or trenching results will provide a basis for determining soil boring locations, which will be advanced in accordance methods and sampling approach described in **Section 3.2.2**. Sample locations will be selected within and immediately surrounding identified waste area and/or impact soil to determine the nature and extent of contamination.

3.2.4 Asphaltic Surficial Material Characterization

As discussed in **Section 3.2.1**, black asphaltic material has been observed at the surface throughout the Site. A total of six samples will be collected of the material from various locations across the Site to determine its composition. Sample locations will ultimately be determined based on field observation to ensure potential variability of the material is accounted for, should visual indications of variability be observed. It is envisioned that one sample will be collected from IAC-3, IAI-2, IAI-3, IAI-4 and two samples will be collected from IAI-5.

Samples will be analyzed for VOCs, ~~PAHs~~SVOCs, Total Petroleum Hydrocarbons (TPH) – Volatile Petroleum Hydrocarbons (VPH), and TPH – Extractable Petroleum Hydrocarbons (EPH).

3.3 Sediment and Surface Water Evaluation

The surface water and sediment evaluation program is intended to characterize the nature and extent of potential surface water and/or sediment impacts in on-site surface water and wetland features; evaluate potential migration pathways from on-site surface water and wetland features to the Mermentau River; further evaluate groundwater-surface water connectivity; and aid in assessment of potential risks from surface water and sediment to human health and ecological receptors. In addition, a habitat reconnaissance survey is proposed to evaluate potential ecological receptors that may be exposed to site COPCs (see **Section 3.6**). As discussed during development of the AOC, and as referenced specifically in Paragraph 2 of the AOC Scope of Work, the proposed sediment and surface water sampling program has been designed in an iterative, two-phased manner. During the initial phase of the RI, the proposed program allows for characterization of on-site and background sediments and surface water. These results will then be used in the second phase to inform decision-making related to sample locations and analyses in the Mermentau River, as necessary, to satisfy sediment and surface water-related RI objectives and DQOs, and to address any sediment and surface water-related data gaps and key study questions (See **Section 2.4** and **2.5**, respectively).

3.3.1 Sediment

The initial phase of the sediment evaluation will characterize sediment quality in on-site aquatic and potential wetland features. If preliminary sediment data from on-site aquatic and wetland features with historical or current connectivity to the Mermentau River indicate potential impacts, additional focused sampling will be conducted within the Mermentau River for those constituents with the potential to impact human health or ecological receptors.

A total of 51 sediment sample locations are proposed during the initial phase of RI to characterize sediment quality in on-site aquatic and potential wetland features (**Figure 6**):

- Dry Dock (IAC-7) – 7 locations
- Barge Slip (IAC-6) – 11 locations
- Northern Property Vessel Slip (IAI-6) – 3 locations
- Northern Property Vessel Slip (IAI-7) – 3 locations
- Barge Cleaning Area Drainage Ditch (IAC-5/IAI-3/IAI-4) – 6 locations
- Water Pit #3 (IAC-3) – 4 locations
- Southern Wetland Area (IAI-1) – 7 locations

In addition, 10 sediment samples will be collected from the Mermentau River upstream of the Site to characterize sediment quality outside of the influence of the Site (see **Section 3.5.2**).

Sediment sampling will be conducted to evaluate potential human health and ecological impacts associated with historical operations and to characterize physical and geochemical conditions. Sediment samples will target fine-grained sediment deposits to characterize sediment quality, as these areas are likely associated with higher concentrations of constituents, due to partitioning to fine-grained particles and organic carbon that accumulate in depositional areas. **Figure 6** illustrates the proposed placement of sediment sampling locations; the exact placement of sediment sampling locations will be determined in the field based on observed conditions.

3.3.1.1 Sampling Design

Sediment samples in the vessel slips on the Northern Property, Dry Dock, Barge Slip, Barge Cleaning Area Drainage Ditch, and Southern Wetland Area were selected based on likely points of entry for contaminants to enter water bodies based on understanding of historical operations. Sediment samples will be collected ~~from the Dry Dock, Barge Slip, and Northern Property Vessel Slips~~ from the following general sampling intervals, as measured below the sediment-surface water interface (**Table 2**):

- 0 to -0.5-ft
- 0.5- to 1.0-ft
- 1.0- to 3.0-ft

~~Samples from the Barge Cleaning Area Drainage Ditch and Southern Wetland Area will be collected from the surface interval (0-0.5-ft).~~

The 0-0.5-ft surface sampling interval generally represents the biologically active zone (BAZ) of sediment, where the greatest biological activity is likely to occur (see Appendix A; USEPA, 2015b). This surface interval will be sampled and analyzed for site-related constituents to characterize potential ecological and human health exposure to sediment (see **Appendix A**). Subsurface intervals will also be sampled and analyzed for site-related constituents to characterize sediment quality in deeper intervals that have the potential to impact sediment quality in the BAZ. Exact sampling intervals may be modified in the field based on the observed stratigraphy in the sediment core; sampling intervals will be bounded by distinct changes in sediment strata.

Sediment sampling intervals will be analyzed for the constituents listed in **Table 2**. ~~SVOCs~~ PAHs and metals will be analyzed in samples from each depth interval. In addition, surface samples (0-0.5-ft) will be analyzed for VOCs, acid volatile sulfide–simultaneously extractable metals (AVS-SEM), total organic carbon (TOC), and sediment grain size distribution to support the evaluation of exposure in the BAZ. AVS-SEM analyses provide a general characterization of sediment oxidation-reduction potential (ORP) conditions to support a preliminary assessment of metal bioavailability (USEPA, 2005). TOC data will support the assessment of the distribution and bioavailability of constituents in sediment, as site-related constituents partition to TOC in sediment. Grain size analyses will support the assessment of the distribution of site-related constituents in sediment due to the general association of site-related constituents with fine-grained sediments. At select stations in the Barge Slip (IAC-6) and Barge Cleaning Area Drainage Ditch (IAC5) located northeast and east of USEPA-identified possible point of entry (PPE) #2, surface samples (0-0.5-ft) will also be analyzed for PCBs and dioxin/furans based on previous detections of these constituents (see **Appendix A** for a discussion of historical sampling results). Sediment samples will also be analyzed for physical and geochemical parameters including ORP, pH, and bulk density to support general river characterization and the human health and ecological risk assessment frameworks.

3.3.1.2 Sampling Methods

Sediment samples in the Mermentau River (background samples) and on-site aquatic features that are directly accessible from the Mermentau River (Northern Property Vessel Slips and Barge Slip) will be obtained using a pneumatic vibracorer or equivalent coring device operated from a shallow draft pontoon barge. The coring rig will be equipped with a core barrel with a dedicated liner. The core barrel will be fitted with a nose cone or "cutter" and a core retainer to improve sample retrieval. The sampling vessel will navigate to each sampling location using a differential global position system (DGPS) receiver mounted directly above the coring rig. The vessel will be secured on station using spuds, anchors, or other means, depending on water depth and river conditions. Once the vessel is secured on station, the vibracore with liner or equivalent coring device will be advanced into the sediment to depth to achieve a minimum recovery of four-feet in the sediment core or to the depth of refusal, whichever comes first. The core will be recovered from the river bottom, maintaining the core in a vertical position and capping the bottom of the core barrel prior to removing the bottom of the core barrel from the water. The position of the recovered core will be recorded using the vessel DGPS. Once on board, the core liner will be removed from the core barrel. Overlying water in the sediment core will be drained, the liner will be cut to the recovered core length, and the recovered core will be capped on both ends and staged for sample processing.

Sediment core liners will be split lengthwise and sediment stratigraphy will be documented to describe depositional characteristics to aid in the interpretation of cores. The core liner will be separated from the sediment core by cutting lengthwise along either side of the core liner with electric shears or an equivalent cutting device. When cut on both sides, the core will be split longitudinally into halves using decontaminated stainless-steel wire or a thin, stainless steel knife. The sediment core will be screened with a PID and the readings recorded on the coring log. The exposed halves of the split core will be photographed with a measuring tape to identify sediment depths; the stratigraphy of the exposed core halves will be logged on the field data sheet. Key characteristics in describing the stratigraphy of core layers include changes in color and texture, laminations/bedding and other sedimentary structures, indicators of biological activity (e.g., feeding voids, burrows, root systems, disturbed bedding, etc.), and the depth of the apparent reduction-oxidation potential discontinuity (aRPD).

After observational information of core characteristics has been logged on the field datasheet and the core has been photographed, split core halves will be sectioned into 0-0.5-ft, 0.5-1.0-ft, and 1.0-3.0-ft sampling intervals, as described above. Samples for volatile constituents (VOCs and AVS/SEM) will be collected directly from the core prior to any manipulation of the sample. Samples for non-volatile constituents will be removed from the core sections at designated intervals using a dedicated utensil, avoiding sediment that has contacted the core liner to the greatest extent practicable. Sediment removed from each interval will be placed in stainless steel trays or dedicated containers and homogenized to a consistent color and texture. Aliquots of the homogenized sample for each interval will be transferred to laboratory-supplied sampling containers until the requisite volume for analysis has been obtained. Processed samples will be placed immediately on ice and maintained at a temperature of 4 °C until receipt by the analytical laboratory.

Sediment sampling in on-site aquatic and wetland features that are not directly accessible from the Mermentau River (Dry Dock, Water Pit #3, Barge Cleaning Area Drainage Ditch, and the Southern Wetland Area [IAI-1]) will be conducted manually from a jonboat or equivalent sampling vessel using hand coring tools (e.g., AMS multi-stage sludge sampler, direct push coring, etc.) or grab sampling techniques (e.g., Ponar sampler, Ekman sampler, trowel, etc.), depending on site conditions. In the Dry Dock and Water Pit #3, sediment cores will be collected ~~and sectioned into 0-0.5-ft, 0.5-1.0-ft, and 1.0-3.0-ft sampling intervals~~, using the procedures described above.

Samples from the Barge Cleaning Area Drainage Ditch (IAC-5) and Southern Wetland Area (IAI-1) will be collected ~~from the surface interval (0-0.5-ft)~~ using coring or grab sampling techniques, as determined based on observed site conditions. To the degree possible, sediment cores will be collected and sectioned into 0- to 0.5-ft, 0.5- to 1.0-ft, and 1.0 to -3.0-ft sampling intervals. Collection of competent sediment cores to a depth of 3.0 ft may be limited in these areas due to accessibility restrictions. Surface cores from these areas will be processed consistent with the procedures described above. If grab samples are obtained from these areas, samples for volatile constituents (VOCs and AVS/SEM) will be collected immediately following the retrieval of the grab sample and prior to any manipulation of the sediment. Following the collection of volatile samples, the remaining sediment in the grab sample will be homogenized to a consistent color and texture and aliquots of the homogenized sample will be transferred to laboratory-supplied sampling containers until the requisite volume is obtained. Processed samples will be placed immediately on ice and maintained at a temperature of 4 °C until receipt by the analytical laboratory. The position of sediment sampling locations in the Barge Cleaning Area Drainage Ditch and Southern Wetland Area will be recorded using a hand-held GPS unit with sub-meter accuracy.

3.3.2 Surface Water

The initial phase of the surface water evaluation will characterize surface water quality in on-site aquatic and potential wetland features. If preliminary surface water data from on-site aquatic and wetland features with historical or current connectivity to the Mermentau River indicate potential impacts, additional focused sampling will be conducted within the Mermentau River for those constituents with the potential to impact human health or ecological receptors.

A total of 31 surface water sample locations will be co-located with select sediment sampling locations in on-site aquatic and potential wetland features (**Figure 6**):

- Dry Dock (IAC-7) – 3 locations
- Barge Slip (IAC-6) – 5 locations
- Northern Property Vessel Slip (IAI-6) – 2 locations
- Northern Property Vessel Slip (IAI-7) – 2 locations
- Barge Cleaning Area Drainage Ditch (IAC-5/IAI-3/IAI-4) – 3 locations
- Water Pit #3 (IAC-3) – 2 locations
- Southern Wetland Area (IAI-1) – 4 locations

In addition, 10 surface water samples will be collected from the Mermentau River upstream of the Site at co-located sediment locations to characterize surface water quality outside of the influence of the Site (see **Section 3.5.2**).

Surface water samples will be co-located with sediment sample locations to evaluate potential impacts to surface water quality caused by historical operations or residual sediment impacts. Proposed surface water sample locations within on-site water bodies (Northern Property Vessel Slips, Dry Dock, Barge Slip, Barge Cleaning Area Drainage Ditch, Water Pit #3, and the Southern Wetland Area) were placed at select sediment sampling locations based on review of historical information and biased towards areas where contaminants are most likely to be present and potential exit surface water features (**Figure 6**).

Surface water samples will be collected from the mid-depth of the water body using a peristaltic (or equivalent) pump with dedicated tubing and a decontaminated Kemmerer sampler. Samples will be collected for analysis of VOC, ~~SVOCs~~PAHs, metals, and geochemical parameters (**Table 3)**. Samples for non-volatile parameters will be collected from mid-depth using a peristaltic (or equivalent) pump with dedicated tubing. Unfiltered and filtered samples will be collected for metals analyses. Samples for filtered metal analyses will be field-filtered using an in-line 0.45 µm capsule filter. Samples for VOC analysis will be collected directly from the Kemmerer sampler to minimize loss due to volatilization that may occur when sampling with a peristaltic pump. *In situ* water quality parameters will be measured at the time of sampling using a multi-parameter water quality meter; *in situ* water quality parameters will include dissolved oxygen (DO), specific conductivity, temperature, ORP, salinity, and pH. The positions of surface water samples will be recorded using a GPS with sub-meter accuracy.

3.3.3 Surface Water Staff Gauge Installation

A total of six surface water gauging locations are proposed as part of the initial phase of the RI. Proposed surface water gauging locations co-located in close proximity to monitoring well locations to support evaluation of surface water-groundwater interactions. Staff gauges will be constructed by affixing a graduated staff gauge to a pole or uni-strut, which will be driven approximately two feet into the water body sediments. Staff gauge locations and the top of gauge will be surveyed using GPS technology to facilitate surface water elevations at each proposed location.

3.4 Groundwater Evaluation

The Groundwater Evaluation program is designed to better refine the current understanding of groundwater flow direction, that nature and continuity of coarser-grained inclusions that will govern lateral groundwater flow, potential groundwater-surface water interactions, groundwater quality across the Site, and soil properties and geochemical conditions impacting potential groundwater contaminant fate and transport mechanisms. In addition, a soil core will be collected of the clay matrix separating the upper Prairie Complex from the underlying Chicot Aquifer to assess the potential for shallow groundwater to reach the Chicot Aquifer. Current understanding of Site geology and hydrogeology is provided in **Section 2.2** and further discussed in the preliminary CSM (**Appendix A**).

3.4.1 Monitoring Well Installation

A total of ten new permanent groundwater monitoring locations (i.e., groundwater monitoring wells) will be installed across the Site, as shown in **Figure 7,** to evaluate groundwater flow direction in the shallow aquifer, potential impacts to groundwater, and water quality properties. Groundwater monitoring locations were selected to supplement and expand the existing monitoring well network and enhance understanding of groundwater conditions Site-wide. Two of the monitoring wells are located in close proximity to existing wells. The new monitoring well proposed near existing monitoring well MW-2 is being installed to confirm the presence of NAPL in the area and better define the stratigraphic interval in which light non-aqueous phase liquid (LNAPL) is entering the well. The new monitoring well in close proximity to existing MW-3 will be screened at a deeper interval to evaluate potential head differences between shallow and deeper coarse-grained zones. Monitoring wells are proposed in IAI-4 and IAC-4 to evaluate the potential groundwater impacts from historical operations. The monitoring well in IAI-4 is being installed based on a request from USEPA during the RI/FS scoping meeting held on March 30, 2017 due to an aerial photograph that depicted a possible low-lying area or pit. The monitoring well in IAC-4 is being installed based on historical reports of landfilling activities in the area.

Using equipment capable of both direct push and hollow stem auguring, a boring will be advanced fifteen feet beyond the observed saturated interface. Soil cores will be logged for lithology in accordance with USCS guidance and will document additional information including the recovery length, presence of fill and/or native material, staining/discoloration, odors, the presence of groundwater or perched water, the presence of NAPL, and PID readings. PID readings will be collected in one-foot intervals throughout the boring by screening the soil core. Headspace PID readings will not be collected at monitoring well locations as soil sampling is not proposed. To the degree possible, monitoring well locations will be co-located with judgemental soil sample locations.

Once the target depth has been reached, direct push tooling will be removed and the boring will be drilled to depth using methodology capable of drilling a boring diameter sufficient for installation of a permanent two-inch groundwater monitoring well. A two-inch polyvinyl chloride (PVC) riser with a five-foot 0.010 slotted screen will installed. The zone to be screened will be determined in the field and biased towards zones exhibiting coarser-grained deposits (i.e. silts and fine sands rather than clay). The well will be completed with an appropriately-sized sandpack, tremie-grouted using a bentonite/cement slurry mix, and completed with above grade well protectors in accordance with applicable SOPs. Well depths and final screen lengths will be determined based on field conditions and observations.

A licensed surveyor will survey the latitude and longitude of each new monitoring well, as well as the elevation of the top of PVC casing and the top of ground surface to the nearest 0.01 ft.

3.4.2 Monitoring Well Development

Following a minimum of 24 hours after installation, each of the new groundwater monitoring wells will be developed in accordance with SOP No. 44 (see FSP, **Appendix B**). Additionally, the five previously-installed site groundwater monitoring wells will be re-developed so that the monitoring wells can be used for groundwater evaluation. All purged groundwater will be containerized and characterized per the guidance stated in the FSP (**Appendix B**).

3.4.3 Groundwater Gauging and Sampling

All previously installed and new Site groundwater monitoring wells will be gauged for static water level to the nearest 0.01 foot using an oil-water interface probe prior to any sampling activities. Each groundwater monitoring well will then be purged using low-flow methodology (as detailed in USEPA, 1996b) using appropriate equipment based on well diameter and depth, including use a flow-through cell for the collection of water field parameters (pH, DO, ORP, temperature, conductivity, turbidity). An analytical sample will be collected after stabilization as indicated in USEPA Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures (USEPA, 1996) has been achieved.

Groundwater analytical samples will be VOCs, ~~SVOCs~~PAHs, metals (unfiltered), total dissolved solids (TDS) and geochemical and physical parameters in accordance with **Table 4**. It is envisioned that a minimum of four quarterly sampling events will be conducted during the initial phase of the RI to assess possible seasonal changes in groundwater quality.

3.4.4 Non-Aqueous Phase Liquids Characterization

Based on historical information, LNAPL is anticipated to be encountered during subsurface investigation activities. LNAPL is currently present in existing monitoring well MW-2 and, as described in **Section 3.4.1**, an additional monitoring well is proposed in that area to confirm the presence of LNAPL. RI activities will include sampling of LNAPL from existing monitoring well MW-2 to determine the chemical and physical characteristics of the LNAPL. If LNAPL accumulates in other monitoring wells, a sample will also be collected from those wells to determine if characteristics are different than those at MW-2. LNAPL characterization analyses will include VOCs, SVOCs, total petroleum hydrocarbons – volatile petroleum hydrocarbons (TPH-VPH) and total petroleum hydrocarbons – extractable petroleum hydrocarbons (TPH-EPH), density, viscosity, and interfacial tension.

3.4.5 Slug Tests and Aquifer Characterization

The purpose of slug testing is to evaluate the local hydraulic conductivity (K) of the water-bearing zone surrounding the well screen. Because slug tests are single-well tests that do not involve surrounding observation wells, the data they provide represent aquifer conditions in close proximity of the tested well. As such, slug testing will be completed at all Site monitoring wells to determine the range of hydraulic conductivity values at various locations and within various lithologies observed at the Site. Slug testing is a quick and logistically simple method of estimating aquifer properties, which involves inducing an instantaneous change to the water level in a well and then measuring the water levels over time. The rate at which the water level returns to a previously measured static water level is governed by the hydraulic properties of the materials across which the well is screened.

Slug testing is proposed using datalogging transducers and solid slugs to displace water within the wells. The general steps are as follows:

- Install transducers within all test wells
- Collect an initial round of manual measurements from all wells once the transducers have been installed and the water levels are stable following transducer installation
- Begin transducer measurement
- Conduct slug-in/slug-out tests at all wells as follows with manual water level measurements collected in between all tests:
  - Three slug-in/slug-out tests at all fill wells based on relatively high hydraulic conductivity and expected fast rebound timeframes. Field personnel will continue to monitor water levels to determine when 95% recovery of the water levels have occurred prior to initiating a subsequent test
- Collect a final round of manual measurements from all wells prior to removing the transducers.

Analysis of the slug test data will conform to procedures described in American Society for Testing and Materials (ASTM) D4104. Water level data downloaded from the transducers/data loggers will be initially reviewed for completeness in a Microsoft Excel® spreadsheet and subsequently imported into AQTESOLV™ (Hydrosolv Inc.) to finish the analysis using type-curve matching with the appropriate analytical solution that corresponds to applicable groundwater conditions encountered in each test well.

3.4.6 Soil Physical Property Analysis

Two soil samples will also be collected during advancement of the soil boring in the central portion of IAC-4 and near MW-2 in IAC-3. Soil samples will be submitted for soil physical property analyses. One sample will be collected from a coarser-grained zone (i.e. fine sand or silt) and one sample will be collected from a fine-grained zone (i.e. clay). The samples will be collected from the upper saturated zone and submitted for the following analyses:

- Effective porosity
- Fraction organic carbon (*ƒ*oc) dry bulk density
- Volumetric water content.

These aquifer properties will be used to evaluate groundwater and solute transport in this area of the Site. A review of constituent-specific properties (organic carbon partition coefficients [Koc]) and the aquifer property data collected (*ƒ*oc, dry bulk density [ρb], volumetric water content [θ], and seepage velocity [v]), the adjusted solute velocities (vc) for select Site-specific COCs will be calculated. The resulting calculated solute velocities will further future evaluation of contaminant plume stability and processes controlling contaminant flux.

The proposed boring/monitoring well located in close proximity to MW-3 will be advanced into the predominantly clay matrix to facilitate collection of soil core from below the area of likely soil and groundwater impacts. It is anticipated that the boring will be advanced to approximately 50 ft bgs; however, observations of soil lithology will ultimately determine the target depth of the boring. The field geologist will instruct the driller to advance the boring until the proportion of silts and sands are minimal. Upon determining that the depth interval is representative of clays that are relatively free from coarser-grained deposits, a Shelby tube or brass sleeve will be advanced into the clay so that an undisturbed soil core is obtained. The undisturbed soil core will be sealed on both ends. The sample location and depth will be recorded on the outside of the soil core and packed for shipping. The soil core does not need to be placed on ice. The sample will be shipped to the laboratory for analysis of vertical conductivity (Kv). The Kv value will be used to assess the potential for groundwater to migrate vertically from the upper zone, through the 100-200-foot clay layer and into the Chicot Aquifer.

3.4.7 Transducer Deployment

Transducers will be installed in all monitoring wells that are free of LNAPL to evaluate changes in groundwater level and assist in evaluation of groundwater - surface water interactions. Transducer data will also be used to assist in evaluation of groundwater flow direction(s) across the site. Transducers will be deployed into monitoring wells below the anticipated low level of groundwater fluctuations and will be equipped with vented cables to account for changes in barometric pressure. Transducer data will be collected for a duration of one year to ensure seasonal variability is accounted for.

3.5 Background Sampling

This section describes the scope of work for background sampling proposed for the Site. The goal of the background sampling is to characterize the type and extent of COPCs in the areas determined to be hydraulically upgradient (i.e., background) of known sources of impacts. The results of the background investigation will provide a baseline of concentrations for analyzed constituents and will assist with evaluation and interpretation of the data collected during the investigation and data evaluation performed as part of the risk assessment. Background sampling includes surface soils, sediment, and surface water.

3.5.1 Surface Soils

A total of 10 background surface soil sample locations are proposed to be sampled from 0-1.0 ft bgs. Background sampling locations will be determined based on field observations, but are envisioned to be collected from the western adjacent property to the Site. Sampling will be conducted with methods described in **Section 3.2.1**. All sampling devices will be decontaminated prior to use and between boring locations according to procedures described in the FSP (**Appendix B**). Surface soil sample borings will be closed through formation collapse and backfilling with cuttings. The recovered soil will be described in the field and screened using a PID. Sample records will be recorded in a bound field book. A sufficient volume will be collected from the given interval at each location and homogenized prior to sample collection for laboratory analysis.

Background surface soil samples are proposed to be analyzed for PAHs and TAL metals. Additionally, soil samples will also be analyzed for TOC, grain size, ORP and pH. The soil sampling program is summarized in **Table 1**.

3.5.2 Sediment and Surface Water

Background sediment and surface sample locations are located upstream of the Site, as shown on **Figures 4 and 6**. A total of 10 background sample locations are proposed as part the first phase of the RI. Ten stations were proposed based on the minimum recommendation of 10 samples to support the calculation of a background threshold value (BTV) using USEPA ProUCL 5.1 software (USEPA, 2015a).

Background sediment samples from the Mermentau River will be collected in areas that are outside of the potential influence of the Site at locations with similar sediment characteristics (e.g., grain size distribution, TOC content, etc.) to those observed at sampling locations adjacent to the Site. **Figure 6** illustrates the proposed placement of background sediment sampling locations; the exact placement of background sediment sampling locations will be determined in the field based on observed conditions. Background sediment samples will be collected from the 0-0.5-ft, 0.5-1.0-ft, and 1.0-3.0-ft sampling intervals using coring techniques and sampling procedures described in **Section 3.3.1.2**. Background sediment samples will be analyzed for VOCs, ~~SVOCs~~PAHs, metals, AVS/SEM, grain size distribution, and TOC in sampling intervals consistent with samples collected at the Site. The positions of background sediment samples will be recorded using a GPS with sub-meter accuracy.

Background surface water samples will be co-located with background sediment sampling locations. Background surface water samples will be collected at mid-depth in the water column using the same sampling techniques and procedures described in **Section 3.3.2**. Surface water samples will be analyzed for VOC, ~~SVOCs~~PAHs, metals (filtered and unfiltered), and geochemical parameters, consistent with surface water sampling conducted at Site locations. The positions of background surface water samples will be recorded using a GPS with sub-meter accuracy.

3.6 Habitat Reconnaissance Survey

As part of pre-mobilization activities, a habitat reconnaissance survey will be conducted by a qualified ecologist to provide qualitative descriptions of available habitats on-site and in the Mermentau River adjacent to the Site. The findings of the reconnaissance survey will be used to confirm and refine the Conceptual Exposure Model (CEM) for human health and ecological exposure to ensure that the sampling activities described in the preceding sections are adequate to support the human health and ecological risk assessment frameworks, described in **Sections 3.7** and **3.8**, respectively. The reconnaissance survey will qualitatively characterize existing habitats on-site, including assessing the presence/absence of potential wetland features. Based on the qualitative habitat characterization, potential ecological receptors will be identified within each habitat type. Potential ecological receptors identified during the qualitative survey will be evaluated relative to the preliminary ecological receptor categories identified in the ecological CEM and ecological risk assessment framework to assess whether modifications to the CEM are warranted (**Appendix A**). In addition, the habitat reconnaissance will be used to evaluate assumptions pertaining to potential human health exposure as presented in the human health CEM (**Appendix A**).

In addition to evaluating the assumptions of the CEM, the findings of the habitat reconnaissance will be used to support pre-mobilization planning for the implementation of the sampling activities described above. The reconnaissance will be used to evaluate the feasibility of sampling at proposed locations, particularly sediment sampling locations, and to identify potential issues associated with access and/or health and safety. Information gained from the reconnaissance will be used to make modifications to the sampling approach in advance of mobilizing into the field that will enhance health and safety procedures and increase sampling efficiencies.

3.7 Human Health Risk Assessment

A human health risk assessment (HHRA) and a SLERA will be conducted to evaluate the potential threat posed by environmental conditions at the Site in the absence of any remedial action. The HHRA and SLERA will provide the basis for determining whether remedial action is necessary in the various exposure areas identified at the Site as well as the extent of remedial action required. A Risk Assessment Work Plan (RAWP) will be prepared after the completion of Site characterization activities to provide a detailed description of the methodology and assumptions to be utilized in completing the HHRA and SLERA. A Risk Assessment Report that documents the entire risk assessment process and presents the results of the HHRA and SLERA will be prepared following the completion of the final phase of the Site characterization (i.e., either Phase 2 Site Characterization or after any subsequent phases of Site characterization, if necessary). The overall approach and a general description of the scope of work to complete the HHRA and SLERA are provided below.

3.7.1 Human Health Framework

The purpose of the HHRA is to evaluate whether potential human health risks associated with future land use exposures to COPCs are acceptable after implementation of mitigation and correction actions. The technical approach for the HHRA consists of an update of preliminary CEM and the presentation of the methodologies for the components of the HHRA including:

- Hazard identification - statistical evaluation of data and selection of COPCs
- Exposure assessment – calculations of the exposure point concentrations (EPC) of COPCs in each medium, identification of the exposure assumptions are identified, and methodology for calculation of the daily intake dose based on magnitude, frequency, and duration of exposures over a specified exposure period of time
- Toxicity assessment – relationship between the potential extent of exposure and toxicological effects of the exposure for each COPC-specific toxicity criteria are presented, including cancer slope factors (CSFs) or unit risk factors (URFs) for carcinogens and reference doses (RfDs) or reference concentrations (RfCs) for non-carcinogens
- Risk characterization - integration of the toxicity and exposure to derive quantitative estimates of human health risks for carcinogens and non-carcinogens, and presentation of the uncertainties and limitations inherent in the estimation of the potential risks, and the potential risks associated with background concentrations

The primary regulatory guidance for conducting the HHRA is presented in a series of USEPA publications: Risk Assessment Guidance for Superfund, Volume I: Parts A through F (USEPA 1989, 1991a, 1991b; 2001, 2001, 2004, and 2009); commonly referred to as RAGS Part A thru Part F. The USEPA has issued additional risk assessment guidance beyond that which is presented in RAGS. The purpose of this additional guidance is to provide risk assessment guidance that, when used in conjunction with RAGS, reflects current scientific knowledge. In addition, the Risk Evaluation/Corrective Action Program (RECAP) Guidance (LADEQ 2003) will be used in conjunction with the USEPA guidance, as applicable.

3.7.1.1 Conceptual Exposure Model

The use of a CEM provides a means of documenting and periodically updating general facility information and data regarding potential releases to the environment. The CEM also provides a framework for problem definition; aids in the identification of data gaps, which can then be addressed in the investigation; and assists in the identification of appropriate remedial technologies, if necessary.

The preliminary human health CEM presented in the preliminary CSM (**Appendix A**) will be re-evaluated and updated during preparation of the RAWP based upon the results of the final phase of the Site characterization. The updated CEM will assess potential exposure-area specific pathways as incomplete, complete, or potentially complete, and present the rationale considering both current and potential future land use. In addition, the potential receptors associated with the exposure pathways will be presented.

3.7.1.2 Hazard identification

The purpose of the hazard identification process is to summarize the environmental media data, and to screen the data to determine the COPCs that will be evaluated further in the risk assessment process.

Data Used in the Risk Assessment

Data that was collected during the Site investigation activities for soil, groundwater, surface water, and sediment will be assessed in the HHRA. At this time, the collection of aquatic biota for potential fishermen exposure has not been proposed for the first phase of the Site investigation. This RI Work Plan outlines the environmental media data to be collected in the initial phase of the Site investigation activities.

The environmental media data to be used in the HHRA will be managed electronically and compiled by constituent, medium, exposure area, sample location, and sample depth, if applicable. All descriptive and statistical analyses of the data will be performed using ProUCL Version 5.1 that was developed for the USEPA (USEPA, 2015b). The database will include all new Site investigation activities through the final phase of Site investigation.

Selection of COPCs

The purpose of this section is to select COPCs in order to focus the risk assessment on potentially important site-related chemicals for quantitative evaluation. A review of chemical laboratory analytical results from the Site investigations will be conducted to identify COPCs that will be evaluated in the HHRA. The identification of COPCs is based on comparing the maximum measured constituent concentration with toxicity-based screening concentrations. In addition, the frequency that a COPC was detected was also considered in selecting COPCs. In general, chemicals that are detected very infrequently at a site are not likely to contribute significantly to overall risk (USEPA 1989).

Consistent with the recommendations of the USEPA Regional Screening Level (RSL) guidance (USEPA 2016), the RSLs that have a target hazard quotient (THQ) equal to 0.1 will be used to screen the COPCs to address multiple chemicals that may be that non-carcinogenic effects based on the same toxic endpoint and the same mode-of-action. This is also consistent with the LDEQ RECAP Screening Standards that are based on a THQ equal to 0.1. The proposed hierarchy of sources for human health screening criteria for the selection of COPCs are summarized below for soil, groundwater, surface water, and sediments:

- Soil:
  - USEPA Regional Screening Levels for Industrial Sites, THQ = 0.1
  - LDEQ RECAP Screening Standards for Industrial Land Use Scenarios
- Groundwater:
  - USEPA Regional Screening Levels for Tap water, THQ = 0.1
  - LDEQ RECAP Screening Standards for Groundwater Classifications 1, 2 and 3
- Surface Water:
  - LDEQ – Human Health Protection Drinking Water Supply (LAC Title 33 Part IX. Subpart 1; May 2016)
  - EPA National Recommended Water Quality Criteria (NRWQC) – Human Health for the Consumption of Water and Organisms
- Sediments
  - USEPA Regional Screening Levels for Industrial Sites, THQ = 0.1
  - LDEQ RECAP Screening Standards for Non-Industrial Land Use

If a COPC did not have an applicable human health screening criteria, the screening criteria for a surrogate chemical may be used, where available and applicable. Surrogates will be selected based on structural similarity and molecular weight, as well as toxicologically similar effects. If the risk-based screening indicates that potential risks are insignificant, then further action will not be necessary. An insignificant risk resulting from long-term exposure is one in which the concentration of the COPCs is less than the risk-based screening values representing a theoretical excess risk of getting cancer of less than one-in-a million (10^{-6}) or a hazard quotient of less than one (unity) for non-carcinogenic effects.

3.7.1.3 Exposure Assessment

The purpose of the exposure assessment is to predict the magnitude and frequency of potential human exposure to each identified COPC based on the hazard identification. The updated CEM will present the potential receptors by exposure area and media of concern. In the case that the exposures estimated results in an unacceptable hazard or risk, a central tendency exposure (CTE) may additionally be calculated. The CTE is designed to reflect a more typical, though still conservative, exposure.

Exposure Point Concentration

Medium-specific EPCs will be based on reasonable maximum exposure (RME) scenarios for the Site environmental data based on the exposure areas for each receptor and exposure pathway. The RME is defined as the highest exposure that could reasonably be expected to occur for a given exposure pathway at the Site. The RME is intended to account for both uncertainty of the COPC concentration and variability in exposure parameters. If the exposures estimated results in an unacceptable hazard or risk (see **Section 3.7.1.5** below), a central tendency exposure (CTE) may additionally be calculated. The CTE is designed to reflect a more typical, though still conservative, exposure.

The EPC for each exposure area and environmental media will be either the maximum detected concentration or the 95-percent upper confidence limit of the mean (UCL). If a sufficient number of data points (i.e., greater than 10), either in the sample set or distinct observations, are not available for the exposure scenario, the maximum detected concentration will be selected as the EPC. The 95-percent UCL will be calculated using ProUCL, and will be dependent on the distribution of the data. If the 95-percent UCL exceeds the maximum detected concentration of a COPC, then the corresponding maximum concentration will be used as the EPC. Recommendations provided by the ProUCL software for the evaluation of sample results qualified as below the detection level (non-detect) will be followed.

Exposure Assumptions, Equations, and Models

The exposure assumptions to be used in the HHRA are based on site-specific conditions or default exposure assumptions presented in the following guidance documents:

- USEPA RSLs Table (EPA, 2016)
- Exposure Factors Handbook (USEPA, 2011)
- Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part E - Supplemental Guidance for Dermal Risk Assessment (USEPA, 2004)
- Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Part F - Supplemental Guidance for Inhalation Risk Assessment (USEPA, 2009)
- RECAP guidance (LADEQ, 2003)

Intake dose equations for ingestion and dermal contact and exposure concentration (EC) equations for inhalation to estimate non-carcinogenic health effects - average daily intake (ADI) and carcinogenic effects - lifetime average daily intake (LADI) will be based on the USEPA RSL exposure equations. Modeling of environmental concentrations or exposures (e.g., bioaccumulation in aquatic biota) will be conducted using exposure assessment tools presented on the USEPA EXPOsure toolBOX (EPA ExpoBox) website, or other resources (e.g., Virginial Department of Environmental Quality's construction trench vapor intrusion model) as well as the RECAP guidance (LADEQ, 2003).

3.7.1.4 Toxicity Assessment

The purpose of the toxicity assessment is to determine the relationship between the dose of a COPC taken into the body, and the probability that an adverse effect will result from that dose. The primary sources of toxicity values to be used in the risk assessment are based on the USEPA Superfund hierarchy of human health toxicity values, and they will be used to evaluate risk from both chronic and sub-chronic exposures.

Sources of toxicity values in order of preference are as follows:

- USEPA Integrated Risk Information System (IRIS)
- Provisional peer-reviewed reference toxicity values (PPRTVs)
- Agency for Toxic Substances and Disease Registry's Minimal Risk Levels
- California Environmental Protection Agency Office of Environmental Health Hazard Assessment (OEHHA) risk assessment health values
- Other sources (screening values from "PPRTV Appendix" sources and other specific individual toxicity values and EPA Superfund program's Health Effects Assessment Summary Table)

Quantitative estimates of the potency of COPCs include two sets of toxicity values, one for carcinogenic effects and one for non-carcinogenic effects. For carcinogenic effects, the USEPA assumes a non-threshold toxicological mechanism that assumes there is no level of exposure that does not pose a probability that an adverse effect will result from that dose. Toxicity criteria for non-carcinogens assume that there is a threshold effects level, below which adverse health effects are not expected to occur.

3.7.1.5 Risk Characterization

The purpose of the risk characterization is to provide a conservative estimate of the potential risk resulting from exposure to COPCs identified in the environmental media of the Site. Included in this section is a quantitative estimate of potential carcinogenic and non-carcinogenic risks for each complete exposure pathway for each receptor.

Carcinogenic risks will be estimated in the HHRA by summing the excess lifetime cancer risk over all the exposure pathways for a receptor group. For non-carcinogens, the individual hazard quotients (HQs) will be summed for an overall hazard index (HI). If the HI is less than 1.0, then no adverse health effects are likely associated with exposures at the Site.

Cancer risks will be expressed as the upper-bound, increased likelihood of an individual developing cancer because of exposure to a particular COPC. The following equation is used to estimate the excess cancer risk:

$Cancer\ Risk = LADI \times CSF \text{ or } EC \times IUR$

- *LADI* = Lifetime average daily intake (mg/kg-day)
- *CSF* = Cancer Slope Factor $(\text{mg/kg-day})^{-1}$

- *EC* = Exposure concentration (µg/m^3)
- *IUR* = Inhalation Unit Risk (µg/m^3)$^{-1}$

Cancer risk estimates for individual chemicals are summed by media and exposure pathway to generate an estimate of cumulative risk. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) states that for carcinogens, acceptable exposure represents an excess upper-bound lifetime cancer risk to an individual between 10^{-6} and 10^{-4}. Cancer risks less than 1×10^{-6} are generally considered *de minimis*.

Noncancer effects from exposure to a COPC are expressed as a HQ. An HQ is the ratio of the estimated intake (ADI) or EC of a COPC to the corresponding COPC-specific *RfD* or *RfC*. The following equation is used to estimate the noncancer risk:

Hazard Quotient = ADI/RfD or EC/RfC x CF

- The correction factor CF = 1000 µg/mg

The COPC- and pathway-specific HQs are combined as a HI, which is then compared to a typically accepted benchmark level of 1.0. If the HI exceeds 1.0, then combined site-specific exposures exceed the RfDs and/or RfCs, and there is a potential for noncancer adverse effects to result from exposure to Site COPCs under the evaluated receptor scenario(s). However, if the total HI is greater than 1.0, separate endpoint-specific HIs will be calculated based on target organs (e.g., HQs for neurotoxins are summed separately from HQs for renal toxins). Only if a target-organ-specific HI is greater than 1.0 is there a reason for concern about potential health effects for that target organ and receptor.

3.7.1.6 Uncertainty Analysis

The procedures and inputs used to assess potential human health risks in this and similar HHRAs are subject to a wide variety of uncertainties. In general, there are five main sources of uncertainty and variability in risk assessments of well-characterized sites:

- environmental chemistry sampling and analysis
- environmental parameter measurements
- fate and transport modeling
- toxicological data and dose-response extrapolations
- updated risk assessment methodologies, exposure assumptions, and toxicological data

These sources of uncertainty will be discussed qualitatively in the HHRA.

3.8 Ecological Risk Assessment

An ecological risk assessment (ERA) will be conducted in accordance with *USEPA Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (ERAGS; USEPA, 1997). The functions of the ERA are to (USEPA, 1997):

1) Document whether actual or potential ecological risks exist at the Site;
2) Identify which contaminants present at the Site pose an ecological risk; and
3) Generate data to be used in evaluating cleanup options.

ERAGS prescribes an eight-step process for the assessment of ecological risk to support risk management decision-making. The eight-step process includes several scientific management decision points (SMDPs) for the risk manager and risk assessment team to evaluate and approve or redirect the process (USEPA, 1997). The eight-step ERA process is conducted in a tiered-approach consisting of two phases of risk assessment:

- Screening-Level Ecological Risk Assessment (SLERA): The SLERA includes Steps 1 and 2 of the ERAGs process and represents a preliminary and conservative assessment of potential ecological risks to determine if additional steps in the ERAGS process are warranted.
- Baseline Ecological Risk Assessment (BERA): The BERA includes Steps 3 through 8 of the ERAGS process. If warranted based on the findings of the SLERA, a BERA is conducted to further characterize site-specific ecological risks and to support risk management and remedial decision-making for the protection of ecological receptors.

In addition to ERAGS, other relevant guidance documents that may be consulted to support the ERA process at the Site include, but may not be limited to:

- *Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological Risk Assessments* (USEPA, 2015)
- *Considerations for Developing Problem Formulations for Ecological Risk Assessments Conducted at Contaminated Sites Under CERCLA* (USEPA, 2004)
- *Role of Screening Level Risk Assessment and Refining COCs (Chemicals or Contaminants of Concern) in Baseline Ecological Risk Assessment (*USEPA, 2001)
- *Guidance for the Data Quality Objective Process* (USEPA, 2000)
- *Principles for Ecological Risk Assessment and Risk Management.* (USEPA, 1999)
- *Guidelines for Ecological Risk Assessment* (USEPA, 1998)
- *Role of the Ecological Risk Assessment in the Baseline Risk Assessment* (USEPA, 1994).

The following sections present the general frameworks for the SLERA and BERA processes that will be implemented as part of the RI of the SBA Shipyard Site.

3.8.1 Screening-Level Ecological Risk Assessment

A SLERA will be conducted to initiate the ecological risk assessment process (ERAGS Steps 1 and 2) as part of RI activities at the Site. The SLERA is a simplified risk assessment that provides a preliminary assessment of whether the potential for adverse effects to ecological receptors occurs at the Site under current and future conditions and to identify the constituents of potential ecological concern (COPECs) and the associated exposure pathways, exposure media, and ecological receptors that may require further site-specific assessment as part of a BERA (ERAGS Steps 3 through 8). The SLERA is conducted based on conservative exposure assumptions to provide a high level of confidence in determining a low probability of adverse effects (USEPA, 2001). The conservative assumptions of the SLERA limit the likelihood of excluding a COPEC and/or an exposure pathway that may pose a significant ecological risk before a more comprehensive, site-specific assessment is conducted in the BERA, if warranted.

The SLERA consists of two primary components: 1) screening-level problem formulation and 2) screening-level exposure estimates and risk calculations. These two steps represent an abbreviated consideration of each step in the ecological risk assessment framework that inform decisions regarding the need for additional assessment and the path forward for additional assessment. The following sections describe the primary components of the SLERA in the context of the preliminary ecological CEM developed for the Site.

3.8.1.1 Screening-Level Problem Formulation

The screening-level problem formulation establishes the framework for conducting the SLERA by presenting the ecological conceptual exposure model, which provides the basis for identifying potential ecological effects associated with COPECs and defining the assessment and measurement endpoints to be evaluated in the SLERA. The following sections describe these elements of the preliminary problem formulation as they pertain to the Site.

Ecological Conceptual Exposure Model

A preliminary ecological exposure model was developed to identify potentially complete exposure pathways between suspected source areas and potential ecological receptors of concern that may be present in exposure areas at the Site. Appendix A presents the preliminary ecological CEM that was developed based on available information for the Site and surrounding ecological resources. The preliminary CEM will be refined and updated throughout the ERA process as additional data and information regarding ecological exposures are acquired through RI activities.

The preliminary ecological CEM identified three types of potential ecological exposure areas associated with the IACs and IAIs designated at the Site, as illustrated in **Figure 8**:

- Aquatic Exposure Areas:
  - Dry Dock (IAC-7)
  - Barge Slip (IAC-6)
  - Vessel Slips on Northern Property (IAI-6 and IAI-7)
  - Barge Cleaning Area Drainage Ditch (IAC-5/IAI-3/IAI-4)
  - Water Pit 3 (IAC-3)
  - Mermentau River, if warranted
- Wetland Exposure Areas:
  - Southern Wetland Area (IAI-1)
  - Historical Waste Storage Area (within IAC-4)
- Terrestrial Exposure Areas:
  - Early Successional Land (IAI-5, IAI-4, IAI-3, IAI-2, IAC4, IAC-3, IAC-2)

Ecological receptor categories and potential exposure pathways were identified for the three types of exposure areas identified at the Site. No threatened or endangered species were identified near the Site (approximately 1-mile radius) in the preliminary ecological CEM (**Appendix A**). **Figure 9** illustrates potentially complete exposure pathways identified between suspected source areas and potential ecological receptors categories. Ecological receptors may be exposed via direct contact exposure routes to soil, sediment (including sediment pore water), and/or surface water. Ecological receptors may also be exposed via ingestion pathways to biota, soil, sediment (including sediment pore water), and/or surface water. Further discussion of ecological receptor categories and potential exposure pathways is provided for each exposure area in **Appendix A**.

Preliminary Ecological Effects Evaluation

Based on the preliminary ecological CEM, ecological receptors may be exposed to site-related constituents in soil, sediment, surface water, and biota via direct contact and ingestion pathways (**Figure 9**). Given that the intent of the SLERA is to provide a high level of confidence in determining a low probability of adverse effects, conservative ecological screening values (ESVs) will be used to identify the initial list of COPECs for each direct contact exposure medium that may require further evaluation in the ERA process. Conservative ecological screening criteria for direct contact pathways will be based on chronic, no observed effects concentrations (NOECs) for the protection of survival, growth, and reproductive endpoints. Lowest observed effects concentrations (LOECs), which represent the lowest concentrations at which effects are observed, will also be included in the evaluation of the likelihood of adverse effects. The proposed hierarchy of sources of conservative ESVs that will be used in the initial identification of COPECs for direct contact pathways is summarized below by potential exposure medium:

- Soil:
    - USEPA Ecological Soil Screening Level (Eco-SSL) Guidance (USEPA, 2005)
    - Oak Ridge National Laboratory (ORNL) Ecological Screening Levels
        - Toxicological benchmarks for effects on soil and litter invertebrates (Efroymson et al., 1997a)
        - Toxicological benchmarks for effects on terrestrial plants (Efroymson et al., 1997b)
    - Texas Commission on Environmental Quality (TCEQ[1]) Soil Benchmarks (TCEQ, 2017)
    - Additional literature-based sources or derived criteria, as warranted

- Sediment:
    - Consensus-Based Sediment Quality Benchmarks (MacDonald et al., 2000)
    - NOAA Screening Quick Reference Tables (Buchman, 2008)
    - TCEQ Freshwater Sediment Benchmarks (TCEQ, 2017)
    - Additional literature-based sources or derived criteria (e.g. equilibrium partitioning approach), as warranted

- Surface water:
    - Louisiana DEQ – Freshwater Chronic Criteria (LAC Title 33 Part IX. Subpart 1; May 2016)
    - EPA National Recommended Water Quality Criteria (NRWQC) – Freshwater Criterion Continuous Concentration (CCC)
    - Supplemented by additional sources if LDEQ or USEPA criteria are not available:
        - TCEQ Surface Water Quality Benchmarks (TCEQ, 2017)
        - Additional literature-based sources, as warranted

Potential ecological effects associated with ingestion pathways will be preliminarily evaluated using toxicity reference values (TRVs) based on chronic no observed adverse effects level (NOAEL) doses derived from conservative exposure assumptions. Lowest observed adverse effects levels (LOAELs) will also be included in the evaluation of the likelihood of adverse effects via ingestion pathways. Proposed sources of NOAEL and LOAEL TRVs to support the preliminary evaluation of ingestion pathways include:

- USEPA Ecological Soil Screening Level (Eco-SSL) Guidance (USEPA, 2005)
- ORNL Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al., 1996)
- Additional literature-based sources or derived TRVs, as warranted.

NOECs and NOAELs used in the initial identification of COPECs and preliminary effects evaluation may be refined in the SLERA, as warranted, using alternative criteria that represent a broader range of chronic NOECs and NOAELs values that are protective of survival, growth, and reproductive endpoints (see **Section 3.8.1.2**).

[1] It is noted that representatives from LDEQ stated in the March 30, 2017 meeting that TCEQ Ecological Benchmark values were not preferred by their risk assessors. TCEQ Ecological Benchmarks are recently-reviewed (January 2017) compilations of ecological screening criteria for surface water, soil, and sediment from available sources (TCEQ, 2017). In addition, these compilations include ecological screening criteria derived for many organic constituents lacking screening criteria from other available sources.

Screening-Level Assessment and Measurement Endpoints

Assessment endpoints will be identified in the SLERA that explicitly express the environmental value that is to be protected (USEPA, 1997). Measurement endpoints are qualitative or quantitative observations that will be measured for each receptor category in each exposure area to evaluate the assessment endpoint. Candidate assessment endpoints and measurement endpoints were preliminarily identified for the SLERA based on the preliminary ecological CEM presented in Appendix A. A summary of generalized candidate assessment endpoints and measurement endpoints is provided below for each receptor category and type of ecological exposure area based on the preliminary ecological CEM (**Figure 9**):

Receptor Category	Candidate Assessment Endpoint	Candidate Measurement Endpoint
Aquatic Exposure Areas		
Aquatic plant community	Protection from adverse effects to survival, growth, and reproduction resulting from exposure to site-related COPECs in sediment and/or surface water.	• Qualitative assessment of the vitality of the aquatic plant community
Benthic invertebrate community		• Comparisons of sediment concentrations to NOECs derived for benthic invertebrates
Amphibian community		• Comparisons of surface water concentrations to NOECs derived for amphibians or general aquatic life
Fish community		• Comparisons of surface water concentrations to NOECs derived for fish or general aquatic life
Reptiles		• Qualitative assessment of relative exposures to other receptor categories (e.g., birds)
Semi-aquatic bird and mammal populations		• Comparisons of estimated daily doses to NOAELs derived for birds or mammals
Wetland Exposure Areas		
Wetland plant community	Protection from adverse effects to survival, growth, and reproduction resulting from exposure to site-related COPECs in wetland soil/sediment and/or surface water.	• Qualitative assessment of the vitality of the wetland plant community
Wetland invertebrate community		• Comparisons of sediment concentrations to NOECs derived for benthic and/or terrestrial invertebrates
Amphibian community		• Comparisons of surface water concentrations to NOECs derived for amphibians or general aquatic life
Fish community		• Comparisons of surface water concentrations to NOECs derived for fish or general aquatic life
Reptiles		• Qualitative assessment of relative exposures to other receptor categories (e.g., birds)

Receptor Category	Candidate Assessment Endpoint	Candidate Measurement Endpoint
Semi-aquatic bird and mammal populations		• Comparisons of estimated daily doses to NOAELs derived for birds or mammals
Terrestrial Exposure Areas		
Terrestrial plant community	Protection from adverse effects to survival, growth, and reproduction resulting from exposure to site-related COPECs in terrestrial soil and/or drinking water.	• Comparison of soil concentrations to NOECs derived for the terrestrial plant community • Qualitative assessment of the vitality of the terrestrial plant community
Soil invertebrate community		• Comparisons of soil concentrations to NOECs derived for terrestrial invertebrates
Terrestrial bird and mammal populations		• Comparisons of estimated daily doses to NOAELs derived for birds or mammals

Candidate assessment endpoints were selected for the protection of local populations and communities of representative ecological receptors, given that no threatened or endangered species were identified near the Site (approximately 1-mile radius) in the preliminary ecological CEM (**Appendix A**). The protection of receptor populations and communities, as opposed to individual receptors, is consistent with ERAGs and USEPA *Principles for Ecological Risk Assessment and Risk Management* (USEPA, 1999) if threatened or endangered species are not likely to occur near the Site. Candidate assessment endpoints focused on survival, growth, and reproductive endpoints because these endpoints are the primary lines of evidence used in the evaluation of ecological effects for risk-management decision making (USEPA, 1994).

Candidate assessment and measurement endpoints identified above will be re-evaluated following the refinement of the preliminary ecological CEM based on additional data and information through supplemental RI activities. Candidate assessment and/or measurement endpoints may be revised or additional endpoints may be included in the SLERA based on the refinement of the preliminary ecological CEM.

3.8.1.2 Screening-Level Exposure Estimate and Risk Calculation

Screening-level exposure estimates will be conducted in the SLERA using data and observational information generated as part of the RI work tasks, described in **Section 3.0**. As appropriate, other relevant and reliable data available from previous site or regional investigations will also be considered in the SLERA.

Consistent with the conservative intent of the SLERA, preliminary exposure point concentrations (EPCs) for direct contact pathways will be based on the maximum concentrations of COPECs measured in each exposure area and exposure medium. The screening-level exposure estimate for direct contact pathways will be based on the comparison of the maximum EPC to conservative NOEC screening criteria from the sources identified in **Section 3.8.1.1**.

Screening-level exposure estimates for ingestion pathways will be based on comparisons of receptor-specific estimated daily doses (EDDs) calculated from simple dose rate models to TRVs derived from sources identified in **Section 3.8.1.1**. The general form of the dose rate model to calculate EDDs is as follows:

$$EDD_{total} = \frac{[(IR_{diet} \times C_{diet}) + (IR_{substrate} \times C_{substrate}) + (IR_{sw} \times C_{sw})] \times AUF}{BW}$$

where:

EDD_{total}= Estimated daily dose (mg COPEC/kg BW/day)
BW = Body weight (kg)
IR_{diet} = Ingestion rate of dietary items [kg/day, dry weight (dw)]
C_{diet} = COPEC concentration in dietary items (mg COPEC/kg, dw)
$IR_{substrate}$= Incidental ingestion rate of substrate (soil/sediment) [kg/day, dry weight (dw)]
$C_{substrate}$ = COPEC concentration in substrate (mg COPEC/kg, dw)
IR_{sw} = Ingestion rate of surface water (drinking water) (L/day, ww)
$C_{substrate}$ = COPEC concentration in substrate (mg COPEC/L, ww)
AUF = Area use factor for exposure area.

The general form of the dose rate model will be modified for each receptor based on receptor-specific exposure parameters (e.g., feeding behavior, ingestion rates, body weight, etc.; USEPA, 1993; USACHPPM, 2004). Preliminary EPCs for soil, sediment, or surface water inputs into dose rate models will be based on the maximum measured concentration in each exposure medium to represent the most conservative exposure scenario. Concentrations of COPECs measured in dietary items will be estimated using conservative assumptions of bioaccumulation from soil, sediment, or surface water (e.g., USEPA, 2005). An appendix will be included in the SLERA Report that provides model calculations and specific details regarding exposure assumptions and parameters included in the estimation of the EDD for each exposure scenario.

Following the evaluation of screening-level exposure estimates, refined exposure estimates will be presented in the SLERA to focus additional evaluation COPECs and exposure pathways that indicate a potential for adverse effects based on the most conservative exposure assumptions. Refined exposure estimates may include consideration of alternative criteria that represent a broader range of chronic NOECs and NOAELs values that are protective of survival, growth, and reproductive endpoints (see **Section 3.8.1.1**). LOEC and LOAEL endpoints may also be evaluated to assess the likelihood of adverse effects based on exposure to concentrations or doses known to be associated with an adverse effect on survival, growth, or reproduction. Refined exposure estimates may also consider alternative EPCs that are more representative of exposure conditions within an exposure area. The technical basis for the refinement of exposure estimates will be provided in the SLERA, as warranted.

Potential risk associated with exposure estimates presented in the SLERA will be expressed as a HQ, calculated as the ratio of the EPC to ESV for direct contact pathway and the EDD to the TRV for ingestion pathways:

$$HQ = \frac{EPC}{ESV} \text{ or } \frac{EDD}{TRV}$$

Potential ecological risk may be characterized based on HQs for each pathway, as follows:

- $HQs_{NOEC/NOAEL}$ less than 1.0 indicate limited potential for adverse effects because constituent concentrations result in an exposure that has not been demonstrated to cause adverse ecological effects.

- $HQs_{NOEC/NOAEL}$ greater than 1.0 indicate that an EPC or EDD for the constituent exceeds an ecological benchmark representing a NOEC or NOAEL. The exposure may or may not constitute an actual risk; however, the potential for adverse effects cannot be dismissed and further evaluation is warranted.

HQs calculated based on LOEC ESVs or LOAEL TRVs will be used to assess the likelihood of adverse effects based on exposure to concentrations or doses known to be associated with an adverse effect on survival, growth, or reproduction. These evaluations will be used to identify potential risk drivers within receptor groups and exposure areas.

3.8.1.3 SLERA Summary and Conclusions

The findings of the SLERA will be summarized to clearly identify the assessment procedures used, the potential risks identified, the uncertainties associated with the conclusions. The information included in the SLERA will be used to support an SMDP to guide the ERA process. As prescribed in ERAGs, one of three possible SMDPs will be supported by the results of the SLERA (USEPA, 1997):

1) There is enough information to conclude that potential ecological risks are negligible and therefore no need for remediation on the basis of ecological risk;
2) The information is not adequate to make a decision at this point, and the ecological risk assessment process will continue to Step 3 (e.g., BERA); or
3) The information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted.

The findings of the SLERA will be evaluated for each ecological exposure area identified in the preliminary ecological CEM (see **Section 3.8.1.1**) in the context of the SMDPs. Area-specific recommendations for each ecological exposure area will be presented in the SLERA conclusions to guide further assessment in the BERA, if warranted. The following sections provide the general framework for conducting a BERA.

3.8.2 Baseline Ecological Risk Assessment

As discussed in the previous section, the SLERA findings will be used to support a SMDP and specific recommendations for each ecological exposure area identified at the Site. If the SLERA findings indicate the need for further ecological risk assessment consistent with ERAGS, a BERA Work Plan will be prepared to prescribe the specific data and analyses needed to complete the risk assessment process and to support risk management decision-making. Because the specific data and information needed to develop the BERA Work Plan will be determined based on information acquired during supplemental RI work tasks and the outcome of the SLERA, the following sections provide only a general overview of three primary phases in the BERA process: baseline problem formulation, study design and implementation, and risk characterization. If warranted, specific data objectives and a detailed study plan will be presented in a BERA Work Plan that will be submitted to USEPA for review and approval prior to initiating BERA activities.

3.8.2.1 Baseline Problem Formulation

The purpose of the baseline problem formulation is to re-evaluate the screening-level problem formulation in the context of new information and findings of analyses conducted to support the SLERA. The baseline problem formulation establishes risk assessment goals, characterizes ecological effects of primary COPECs, and updates the preliminary ecological CEM. The refined ecological CEM will be used to define assessment and measurement endpoints to guide the development of the BERA study design and data quality objectives (DQO) process.

COPEC Refinement

An initial step in the baseline problem formulation is to refine the list of COPECs identified in the SLERA to identify those COPECs that are most likely to drive a risk management decision. COPEC refinement in the BERA will be conducted consistent with USEPA *Role of Screening Level Risk Assessment and Refining COCs (Chemicals or Contaminants of Concern) in Baseline Ecological Risk Assessment* (USEPA, 2001). Specific elements of COPEC refinement may include, but may not be limited to:

- Background concentrations. COPECs in exposure areas at concentrations that are not significantly different from background concentrations may represent regional conditions that are not related to site activities.
- Frequency and magnitude of detection: COPECs that are infrequently detected (< 5 percent) or detected at concentrations slightly exceeding the conservative ESVs (HQs near 1.0) are not likely to drive risk management decisions
- Dietary considerations: COPECs that serve as essential nutrients (e.g., iron, magnesium, sodium, and potassium) typically pose little ecological risk

As previously discussed, the initial refinement of COPECs may be included as part of the refined exposure estimate and risk characterization in the SLERA to focus recommendations for additional evaluation COPECs and exposure pathways.

Refined Ecological Conceptual Exposure Model

During the development of a BERA Work Plan, substantially greater information and data will be available from supplemental RI tasks and SLERA findings to re-evaluate the preliminary ecological CEM presented in Appendix A. Refinement of the ecological CEM based on this new information is fundamental to the effective and efficient design of additional data collection activities to support the BERA. Key elements of the ecological CEM that will be re-evaluated as part of the BERA problem formulation include, but may not be limited to:

- Exposure areas: Ecological exposure areas will be re-defined based on the outcome of the SLERA and only those areas where a more thorough assessment is warranted will be further evaluated in the BERA.
- Ecological receptor categories: The completeness and appropriateness of ecological receptor categories selected in the SLERA will be reviewed and refined, as warranted, for any exposure area that is further evaluated in the BERA. The review of ecological receptor categories in the refined ecological CEM will include updated queries regarding the potential occurrence of special status species (**Appendix A**). Additional information gained during the SLERA regarding habitat use, feeding behavior, home range, and other site-specific information pertaining to ecological receptors will be incorporated into the refined ecological CEM.
- Exposure pathways: Potential exposure pathways will be re-evaluated based on the SLERA findings to assess fate and transport properties of COPECs that may influence mobility and/or exposure routes to receptor categories. Assumptions regarding the depth of the BAZ will also be reviewed to evaluate potential exposure pathways to subsurface sediments.
- Bioavailability: The refined ecological CEM will include an evaluation of the site characteristics that may influence the bioavailability of COPECs in site exposure media. Available literature regarding the bioavailability of key COPECs will be reviewed to identify potential parameters that may be included in a site-specific bioavailability assessment.
- Bioaccumulation/biomagnification: The relative importance of COPECs that bioaccumulate or biomagnify will be evaluated in the refined ecological CEM to identify potential data gaps that may be addressed in the BERA. The evaluation will consider the benefit of site-specific data

collection and advanced modeling approaches (e.g. probabilistic models) to improve upon simplified dose rate models used in the SLERA.

Assessment Endpoints and Risk Questions

Following the refinement of the ecological CEM, assessment endpoints evaluated in the SLERA will be reviewed for completeness and appropriateness based on the receptors and exposure pathways identified for exposure areas that will be further evaluated in the BERA. Risk questions will be formulated to identify specific, measurable ecological characteristics that may be used to evaluate each assessment endpoint. Refined assessment endpoints and risk questions will establish the basis for selecting measurement endpoints and developing the baseline ecological risk assessment study design.

3.8.2.2 Baseline Ecological Risk Assessment Study Design

Based on the baseline problem formulation, a study design will be developed to identify the data inputs or measurement endpoints necessary to evaluate risk based on the assessment endpoints and risk questions.

Measurement Endpoints

Measurement endpoints will be identified based on the assessment endpoints and risk questions formulated in the baseline problem formulation. Measurement endpoints identified in the SLERA will be considered for use in the BERA; however, the selection of measurement endpoints for the BERA will focus on limiting the general exposure assumptions of the SLERA and enhancing site-specific measurements of exposure to support site-specific risk assessment and risk management decision-making.

Study Design and Data Quality Objectives

A detailed study design will be developed to support the evaluation of the identified assessment endpoints and risk questions based on defined measurement endpoints. The study design will be guided by the USEPA DQO process, which is a seven-step planning approach to develop sampling designs for data collection activities that support decision making (USEPA, 2000). The goals of the DQO process in the context of ERAGS are to (USEPA, 1997):

- Clarify the study objective and the most appropriate types of data to collect
- Determine the most appropriate field conditions under which to collect the data
- Specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support risk management decisions.

The BERA Work Plan will present the detailed study design and supporting DQO process to evaluate site-specific ecological risk based on identified assessment endpoints, risk questions, and measurement endpoints defined in the baseline problem formulation.

3.8.2.3 Risk Characterization

Risk characterization in the BERA will focus on establishing causal relationships, if present, between ecological effects and site-specific exposure to COPECs. Risk characterization procedures in the BERA will follow a similar framework to exposure estimation and risk calculations in the SLERA. However, the BERA will focus on more site-specific measurement endpoints and may require a greater level of sophistication of analyses (e.g., probabilistic modeling) to support the evaluation of assessment endpoints.

Ecological Effects Analysis

As part of the risk analysis phase, the preliminary ecological effects evaluation conducted in the SLERA will be refined based on more detailed literature reviews of the potential ecotoxicological effects of primary COPECs and/or the analysis and interpretation of site-specific data to evaluate potential exposure-response relationships observed in exposure areas at the Site. Literature reviews may be conducted to refine ESVs and/or TRVs in the SLERA to better represent site-specific conditions. Site-specific studies may also be conducted as part of the BERA to measure potential effects of receptors exposed to site-specific media in a laboratory or in situ conditions within exposure areas.

Risk Estimation and Risk Description

Risk estimates will be conducted in the SLERA using data and observational information generated as part of the BERA Work Plan. Risk estimates will be based on quantitative comparisons of EPCs to effects thresholds established based on the refined ecological effects analysis discussed in the preceding section. In the BERA, EPCs will be calculated to represent likely exposure scenarios, as opposed to maximum exposure scenarios evaluated in the conservative SLERA. EPCs for risk estimation via direct contact and ingestion pathways will be calculated based on upper confidence of the mean (UCL_{mean}) COPEC concentrations to represent average exposure conditions over an exposure area. Consistent with the SLERA, potential risks associated with exposure estimates presented in the BERA will be expressed as an HQ.

A description of ecological risks will be documented in the BERA for each assessment endpoint based on the findings and interpretations of risk estimates from corresponding measurement endpoints. The risk description provides a weight-of-evidence evaluation of the likelihood and ecological significance of the estimated risks and may be used to support risk management decision-making (USEPA, 1997). Key elements included in the BERA risk description include, but may not be limited to:

- Identifying thresholds for ecological effects for observed exposure-response relationships
- Estimating the likelihood of adverse ecological effects
- Evaluating the spatial extent of unacceptable risk within exposure areas
- Assessing the potential for identified risks to persist in the future, considering the potential for natural recovery once the sources of COPECs or migration pathways to the exposure area are mitigated.

The output of the risk characterization process provides the basis for the conclusions and recommendations that will be presented in the BERA. These recommendations may be used in risk management decision-making to determine the need, extent, and nature of potential remedial actions to address unacceptable ecological risks.

Uncertainty Analysis

A critical component of the BERA is the analysis of uncertainty that is inherent in the ERA process. A thorough uncertainty analysis is necessary to understand how potential uncertainty may affect the risk estimates and associated risk characterization that may be used to support risk management decision-making. Potential elements of uncertainty that may be addressed in the analysis include the adequacy of sampling data, confidence in ecological effects thresholds used in the risk estimation, appropriateness of assumptions included in dose rate models, variations in the responses of individuals and populations of ecological receptors, potential impacts of non-COPEC stressors, etc. The analysis will assess the impact of these uncertainties on overall BERA conclusions and recommendations.

3.8.3 BERA Summary and Conclusions

The findings of the BERA will be summarized to clearly identify the assessment procedures used, the potential risks identified, the uncertainties associated with the conclusions. The BERA findings will be evaluated for each ecological exposure area to support area-specific recommendations to guide risk management decision-making for the Site.

4.0 SUPPORTING DOCUMENTS

In accordance with the provisions of the AOC, the Work Plan includes supporting documents that will be used to guide and support successful implementation of RI activities. Supporting documents include the preliminary CSM, Sampling and Analysis Plan (SAP), and the HASP.

The preliminary CSM (**Appendix A**) provides a technical basis for RI work program rationale and data collection strategies via detailed discussion of site history, site setting, a current understanding of the nature and extent of impacts to environmental media, conceptualized release mechanisms and factors that may influence contaminant fate and transport, and identification of key data gaps.

The SAP is comprised of the following components designed to ensure quality control throughout the data lifecycle (acquisition, analysis, validation, use/reporting):

- FSP (**Appendix B**) – The FSP describes the methodologies associated with field sampling and data acquisition activities proposed during implementation of RI activities. The FSP conforms to the guidance provided in the *Guidance for Conducting Remedial Investigation and Feasibility Studies* (October 1988) under the Comprehensive Environmental Response and Liability Act of 1980 (CERCLA).
- QAPP (**Appendix C**) – The QAPP establishes the sampling and analysis tasks and methods that will be completed in conformance with the project and technical requirements identified in the Work Plan. Quality Assurance/Quality Control (QA/QC) procedures detail the sampling and analysis operations by EHS Support and its subcontractors for this Work Plan. The QAPP conforms to the guidance provided in the *U. S. EPA Requirements for QA Project Plans (QA/R-5*).

The HASP (**Appendix D**) delineates procedures that will allow personnel to work safely and respond quickly and appropriately to Site emergencies. All Site work will be conducted in accordance with Occupational Safety and Health Administration (OSHA) regulations in the Code of Federal Regulations (CFR), Title 29 Parts 1904, 1910, and 1926.

5.0 DELIVERABLES AND SCHEDULE

This section provides a general schedule for completion of the initial phase of RI field investigation activities. Interim deliverables and submittal schedules are detailed in the AOC. The proposed schedule is subject to change based on weather conditions, personnel availability, and USEPA approvals.

As described in **Sections 1.3**, due to the iterative nature of the RI investigation, additional scopes of work will be developed as data is collected and analyzed to foster more efficient and effective decision-making during the RI. In addition, technical memorandums, as necessary, may be developed to facilitate updates to the preliminary CSM and support subsequent scopes of work. These reports will document the work conducted and the preliminary findings of the investigations and recommendations for supplemental data collection or studies. Consistent with AOC, the following key deliverables have been prescribed:

1. Technical Memorandum on Initial Site Characterization and Recommendations for Supplemental Data Collection (if necessary)
2. Work Plan for Supplemental Data Collection (if necessary)
3. Draft and Final SLERA Report
4. Draft and Final BHHRA and BERA (if necessary) Work Plan(s), SAP, and HASP
5. Draft and Final BHHRA and BERA (if necessary) Report(s)
6. Draft and Final RI Report
7. Draft and Final Feasibility Study Work Plan, SAP, and HASP
8. Draft and Treatability Study Work Plan, SAP, and HASP
9. Draft and Final Treatability Study Report
10. Draft and Final Feasibility Study Report

In addition to the above major deliverables, bi-monthly progress reports will be provided in accordance with the AOC. At a minimum, the bi-monthly progress reports will include the following:

a) Description of the actions that have been taken to comply with the AOC during the preceding two-month period;
b) Provision of results of sampling and tests and other data received by the SBA Group;
c) Description of work planned for the next two monthly with schedules related to that specific scope of work and overall project schedule for RI/FS completion; and
d) Description of problems encountered and any anticipated problems, actual or anticipated delays, and solutions developed and implemented to address problems or delays.

Bi-monthly reports will commence upon approval of this Work Plan by USEPA and will continue until issuance of the Record of Decision (ROD) for the Site.

The anticipated schedule, duration, and dependencies of RI activities are provided in **Table 5**.

6.0 REFERENCES

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TABLES

FIGURES

APPENDIX A

Preliminary Conceptual Site Model

APPENDIX B

Field Sampling Plan

APPENDIX C

Quality Assurance Project Plan

APPENDIX D

Health and Safety Plan

APPENDIX E

Visual Sampling Plan Software Plan Details